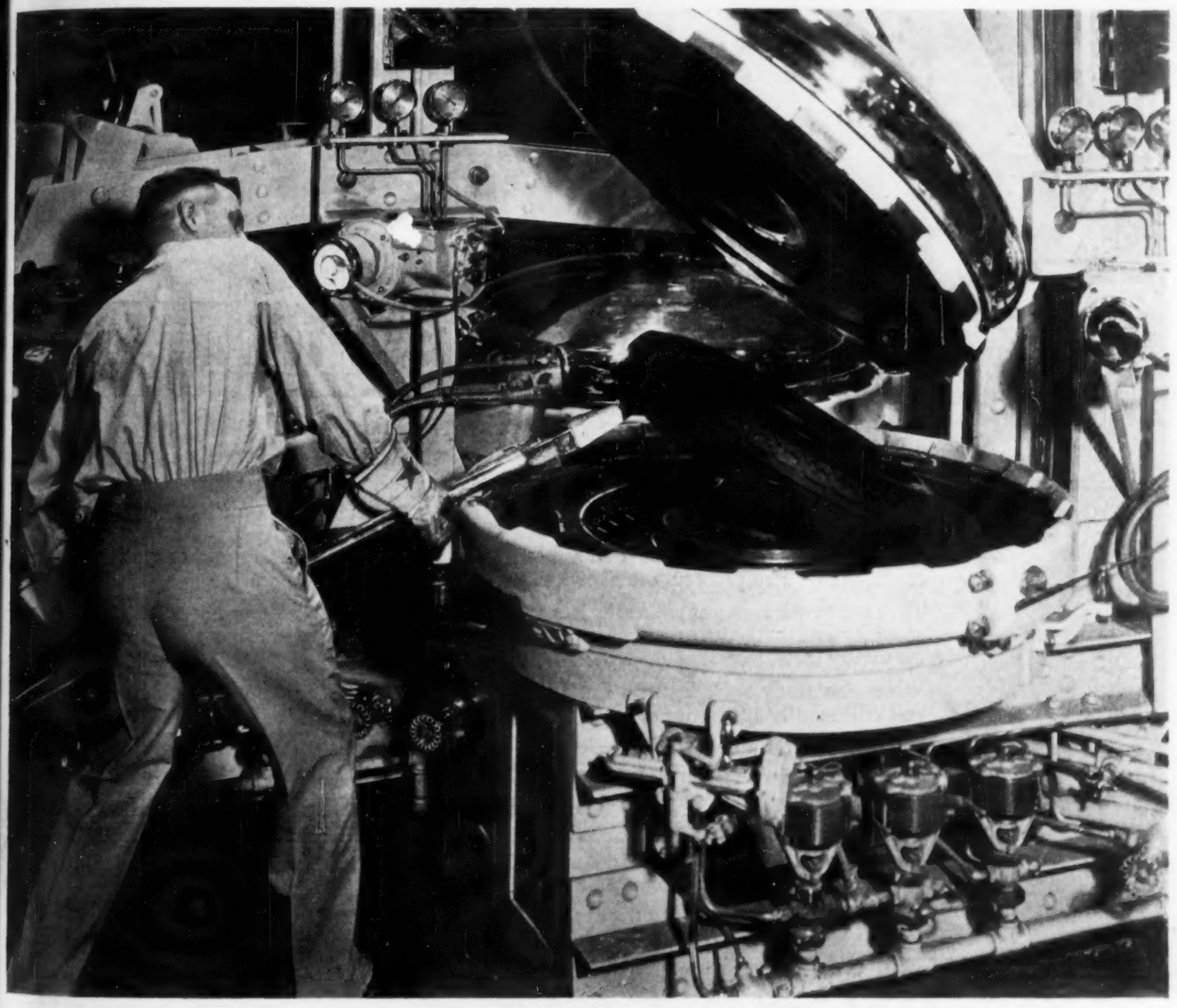
# INSTRUMENTS

## THE MAGAZINE OF MEASUREMENT AND CONTROL

VOLUME 6 OCTOBER, 1933 NUMBER 10



AUTOMATIC JACKET MOLD TIRE VULCANIZERS. Automaticity is due to cycle controller (over operator's right shoulder) and special control valves (lower right corner). *(Courtesy Firestone Tire & Rubber Co.)*

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# INSTRUMENTS

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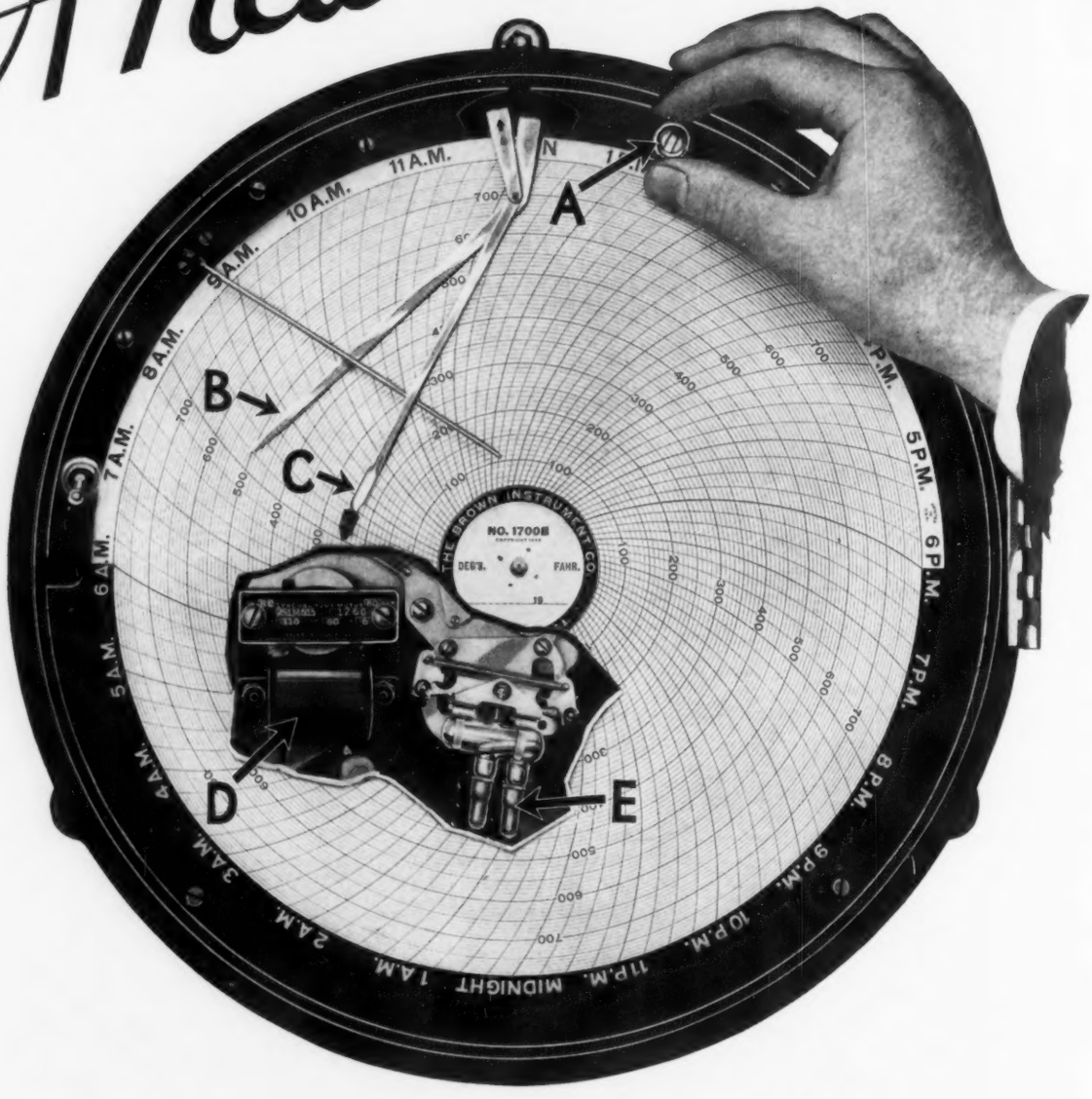


## Records and Controls Temperatures up to 1200° F.

(a) Knob for changing setting of B.
(b) Index showing temperature at which Control is set.
(c) Temperature pen.
(d) Electric motor selects switch position, depending upon relation of C to B.
(e) Mercury in glass switches, capacity 15 amperes at 110 volts, positive in action, are mechanically positioned by Motor D. No power required from pen. Eliminate relays in most applications.

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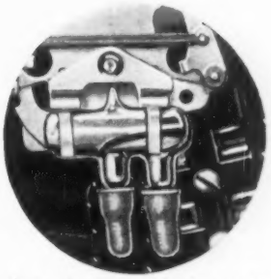

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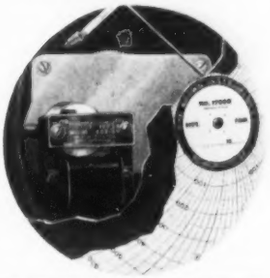

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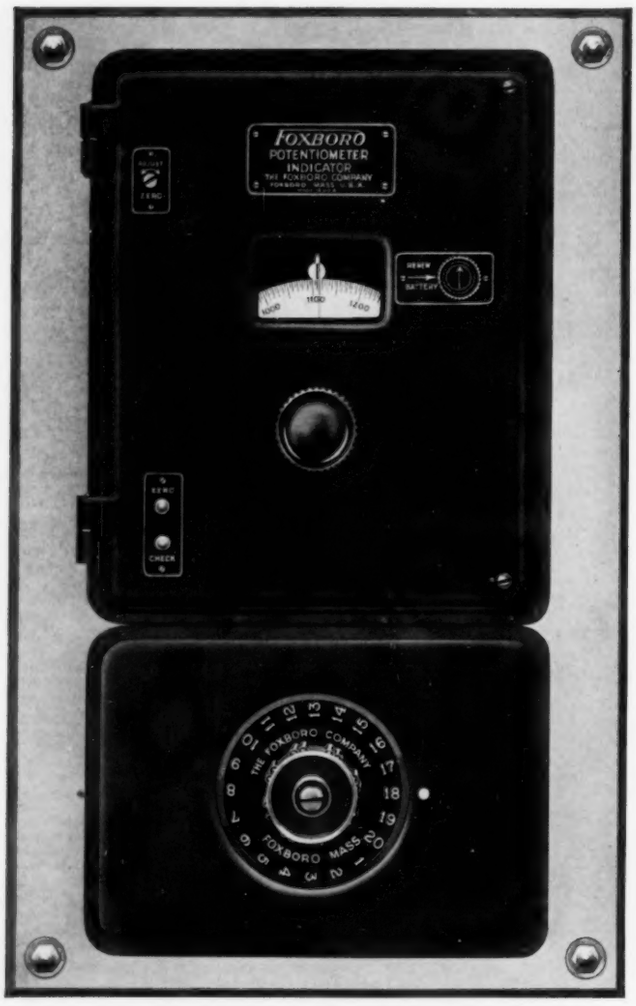


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# EDITORIAL COMMENT

## In This Issue

♦ Current interest in air conditioning has compelled some of our readers to request more articles on humidity measurement and control. Wherefore it gives us pleasure to publish a report of interesting work at the Bell Telephone Laboratories where **A. C. Walker** has been concerned with research on paper and textiles ever since 1923 when he obtained his Ph.D. for graduate work in physical chemistry at Yale.

♦ Another comment made by a few readers is that some of our articles on flow measurement and control last year were a wee bit too deep. "Give us the fundamentals!" **Kenneth H. Warren** does, with respect to **Orifice Metering.**

♦ The instalments on bellows gas meters conclude this month with a discussion of auxiliary instruments for obtaining graphic records, for automatic compensations, etc.—all of them useful for industrial metering.

♦ Thirty-odd **New Instruments** are reported this month, including by chance four new stroboscopes of four distinct types, and quite a few electrical and photoelectric developments. . . . It is probable that one of the five **Book Reviews** deals with a work you need. . . . It is more than probable that some of the **Abstracts** will be "right in your alley."

◆ ◆ ◆

## In the Next Issue

♦ Inadequate knowledge of orifice characteristics in the viscous flow range, and necessarily hit-or-miss methods of accounting for effects of viscosity, have retarded the art of oil flow measurement and control. Our leading article in November will report on a research project initiated three years ago by the Case School of Applied Science and the Bailey Meter Co. The results of some 500 experimental determinations of orifice coefficients in the viscous, the critical and the lower turbulent ranges will be discussed. The authors, Professor G. L. Tuve of Case and Mr. R. E. Sprenkle of Bailey Meter, will present this article at the Annual Meeting of the American Society of Mechanical Engineers in December, and we are scheduling its publication for November in order to benefit not only our readers but the A.S.M.E., which will use it as a "pre-print."

◆ ◆ ◆

## The Front Cover

♦ The present trend of return to "jacket molds" for curing tires one at a time is due to recent developments in special control instruments whereby a one-tire machine is equipped with the equivalent of elaborate cycle controllers that were developed for hydraulic ram vulcanizers containing as many as 35 tires. Automatic cycle controllers—those marvelous "machines that boss machines"—are the result of years of intelligent collaboration by instrument company development engineers and rubber manufacturers' physicists, chemists and specialized Instrumentation Engineers such as Roy W. Brown and G. M. Bosomworth of Firestone.

# "Labor S—ing"

MOB psychology is a curious phenomenon, presenting new aspects every time one watches it, but ever the same under its chameleon skin. It always represents a panicky flight from reality. It always creates totems and taboos; fashions and worships clay-footed idols; keeps time to the medicine man's tom-tom; and sacrifices a milk-white lamb, a lovely virgin, or a pure-minded thinker —preferably a lucid thinker who sees things as they are, for its most efficacious antitoxin is Reason.

Most curious of all, it always is conquered by the very rationality and lucidity which it had stoned, burned, drowned, crucified, drawn and quartered and nailed up tight in a coffin. 'Twas ever thus, since 9999 B. C., when a forest fire threatened a village of our ancestors: They slew the clear-headed youth who, instead of shouting the prescribed incantations, went ahead and cut the brush to make a fire-break, but afterward they adopted his idea and finished his work. Yesterday's heresy is today's orthodoxy.

As we write this (in late September) this nation is not in the grip of mob psychology: it is gloriously *united* in a common effort, which means that its many *different* groups and classes are voluntarily *disciplining themselves* into doing their logically assigned parts, without surrendering their freedom of thought. At present there is but little evidence of mob psychology: our union is genuine intellectual teamwork, *i.e.*, coördinated ideologies.

The distinction is important. It must be kept in mind, lest we slip from team-work to mass thinking and then slide all the way down to mob psychology. This danger always exists in times of stress, when many of the optimates, wearied by bearing the brunt of staving off the "forest fire," gradually lose heart and abjectly refrain from even speaking of whatever constructive ideas are taboo at the time.

The present is a time of stress, and taboos abound. For example, it is heresy to declare that proprietors are entitled to greater profits than the 4% they would get if they bought U. S. bonds instead of building plants; and that technicians are entitled to high salaries or large fees. If we don't watch out we're going to have a State Religion with a credo including the following articles:

Allah is NIRA and NRA is his prophet.

Thy wages shall be increased but thy employer shall not pass on the cost to those who purchase in the market-place.

Thy work hours shall be shortened and thy employer shall be forced to hire thy half-wit uncle Elmer and thy drunken cousin Mike.

Thou shalt get free electricity, free gas, free rides, yea, many good things free but thou shalt not pay more taxes.

Thou shalt never discuss with thy neighbor the possibilities of automatic control and similar evils that reduce the sum total of human drudgery.

Engineers, inventors, managers and all advocates of efficiency are imps of Satan, who make automatic mechanisms do better work than human hands.

Fantastic? Don't be too sure! Even now it has become dangerous to mention labor-s—ing devices. We are politely advised to use such euphemisms as "labor-aiding" or "labor-serving." We mustn't say the naughty word!

Mustn't we? Then hear ye:

LABOR-SAVING DEVICES ARE MORE NECESSARY NOW THAN EVER SINCE 1769 WHEN JAMES WATT PATENTED THE PRINCIPLE OF THE STEAM ENGINE. INSTRUMENTATION IS A BLESSING FOR IT REDUCES THE SUM TOTAL OF WASTE AND DRUDGERY; IT IS A NECESSITY FOR IT CUTS COSTS AND INCREASES PROFITS.

M. F. Behar

# Recording and Producing LOW HUMIDITIES

By A. C. WALKER*

## PART I—SENSITIVE RECORDER FOR LOW RELATIVE HUMIDITY

ONE of the recent improvements in the manufacture and handling of lead-covered telephone cable is the storage of the dried cable cores in ovens whose atmospheres are as free as possible from water vapor. The control of these ovens requires the use of apparatus for continuously measuring and recording the low humidities within them.

The method finally adopted is one which was first applied commercially to the analysis of gaseous mixtures. It is based on the fact that the thermal conductivity of a gas is a function of its molecular weight, and therefore the conductivity of a gaseous mixture varies with the differing proportions of its constituents if these constituents have different molecular weights. The addition of hydrogen to nitrogen, for instance, increases the thermal conductivity perceptibly, for the latter is some fourteen times heavier than the former.

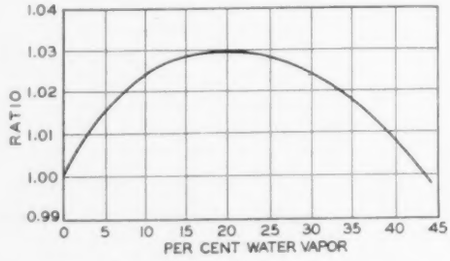


Fig. 1

The differences in the conductivities of atmospheres of different humidities are considerably less, for the average molecular weight of air is only 1.6 times the molecular weight of water vapor. Furthermore the maximum water content of air at ordinary temperatures is but 3.2% by volume, and thus the entire normal range of humidities corresponds to but a very small range of thermal conductivities. In Fig. 1 the ratio of the thermal conductivity of a mixture of water vapor and air to the conductivity of dry air is plotted against the percentage of water vapor contained by volume. Over the whole range of mixtures the relationship is complicated, but in the range of normal atmospheric humidities (below 3%) it is approximately linear. It is, therefore, noteworthy, that apparatus based on this principle could be produced for measuring and recording continuously the water vapor content of air with an accuracy of $\pm 0.0016\%$ by volume, corresponding to less than 0.05% relative humidity under normal atmospheric conditions.

Essentially the apparatus is a Wheatstone bridge whose four arms consist of fine platinum wire mounted axially in tubes (Fig. 2). The air to be analyzed passes first through tubes $X_1$ and $X_2$ in series, through the drier, and finally through tubes $S_1$ and $S_2$ in series. The tubes, formed by drilling holes in a solid block of metal, are 4½ in. long and about 0.4 in. in diameter. The platinum wires, only 0.002 in. in diameter, are gold soldered to heavy platinum lead-in wires. All four wires are heated by a constant current; and if the composition of the air were the same in the four tubes, the wires would all reach the same temperature. The air containing moisture in one pair of tubes has, however, a higher thermal conductivity than the drier air in the other, and thus conducts heat more rapidly from its pair of wires, keeping them at a lower temperature. Since the resistance of platinum varies with its temperature, the difference of wire temperatures unbalances the Wheatstone bridge by an amount which is measured with a sensitive recording potentiometer. The use in the S arms of the dried gas from the X arms cancels the effect which any variations in composition, other than variations in humidity, would have on the readings of the potentiometer.

The required high sensitivity presented difficulties, not only in the design of a suitable thermal conductivity cell and associated recording equipment, but more particularly in securing a satisfactory method of calibration and some means of testing its reliability under conditions comparable to those in service. The apparatus described in Part II, for providing continuously flowing streams of air of controlled, known moisture content was the principal factor contributing to the success of the humidity recorder.

With these air streams of constant composition the conductivity cell could be calibrated and operated with assurance that any observed variations in the recorder were attributable to the circuit itself, and with the problem thus simplified it was soon evident that two factors must be closely controlled, i.e., the heating current and the temperature of the conductivity cell itself.

The heating current (about 0.6 amp. for this design of cell) must be held constant to 0.001 amp. This was accomplished by trickle-charging the storage battery at a rate equivalent to the heating current, thus maintaining constant supply voltage. Furthermore, the rheostat adjustments necessary from time to time to maintain the proper value of the heating current required an indicator more sensitive than the usual electromagnetic milliammeter. Accordingly, a galvanometer was employed in a potentiometer network, to indicate the balance between a standard cell and the voltage drop across a fixed resistance in the heating circuit. The conductivity cell was immersed in an oil bath maintained at constant temperature to within 0.01° C., by means of a reliable, sensitive thermostat control circuit worked out in the Radio Development laboratory of Bell Telephone Laboratories by P. H. Betts.

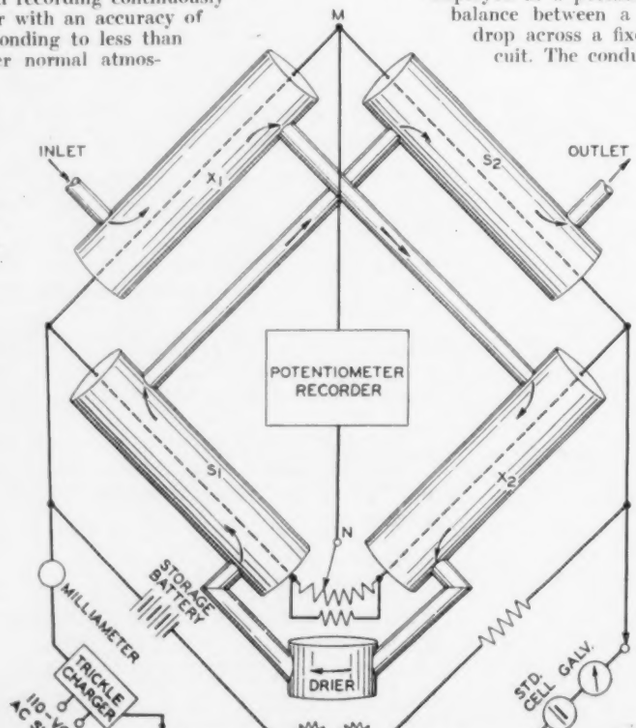


Fig. 2

To verify the sensitivity of this recorder (and the constancy of the calibrating apparatus described in Part II) an overnight test was conducted with a supply of air of 3.96% relative humidity at 25° C. During this test, no change was made in the adjustments of either the recorder or the air supply. Examination of the chart record, and investigation, brought out that the recorder was so sensitive that what appeared to be a temporary drift in the record was due to a slight change in the line-voltage supplied to the trickle charger. In normal operation, of course, this is corrected by adjusting the rheostats which control the heating current, or by the intro-

*Telephone Apparatus Development, Bell Telephone Laboratories, Inc.

duction of ballast lamps in the trickle-charging circuit.

At humidities as low as this, the relationship between bridge unbalance and humidity is sensibly linear. The calibration curve, Fig. 3, shows that at high humidities the linear relation no longer holds, and a given change in bridge unbalance corresponds to a lower change in humidity. In operation, a zero setting is secured by passing dry air through all four arms of the bridge and bringing the pen of the recorder to a predetermined zero line by adjusting a slidewire. The zero line is chosen above the zero line of the chart so that accidental variations causing the pen to go down will be recorded. At the end of the run, the setting of the slidewire is checked.

The calibration curve, Fig. 3, was secured with a circuit having but one tenth the sensitivity of that used in the overnight test. Thus it is evident that the apparatus is adaptable to different ranges. In fact, by employing suitable thermostat temperatures to prevent condensation of water vapor, humidity determinations may be made up to saturation at 200° C. However, increasing the range by bridge circuit alterations and using the potentiometer galvanometer as a deflection instrument necessitates corresponding decreases in sensitivity since the width of the recorder chart is fixed. In the course of our experimental work it was found that the range could be extended with practically no decrease in sensitivity, up to saturated air at relatively high atmospheric temperatures, with no change in the circuit design. This is possible by using the recorder galvanometer as a null-point instrument and calibrating moisture contents against settings of the Kohlrausch slidewire connected as shown in the circuit at the point N (Fig. 2). This has greatly added to the usefulness of the equipment and it is unlikely that this application of the equipment could have been readily determined without the use of the apparatus for furnishing air streams of constant humidity.

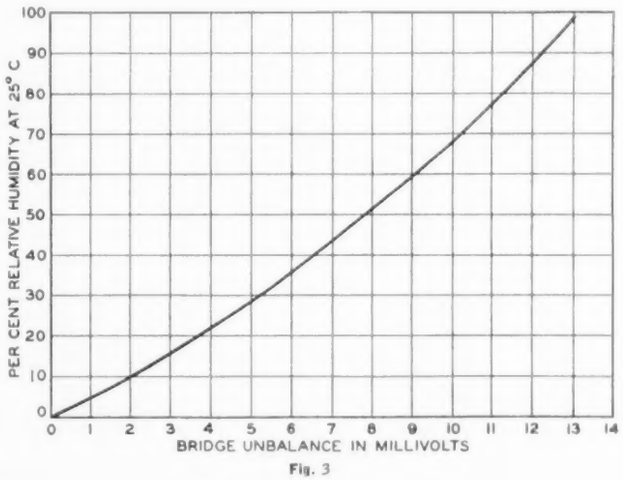

Fig. 3

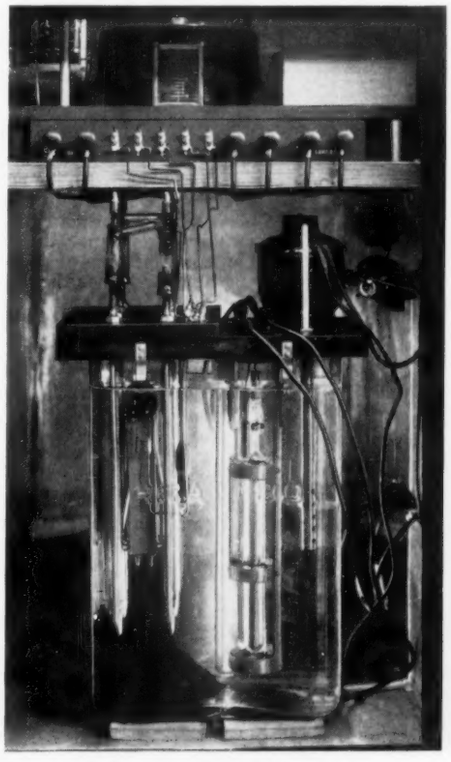
Fig. 4

Installations of the humidity recorder equipment designed and built to our specifications by the Leeds and Northrup Co., are now used by the Western Electric Co. in recording the atmospheric humidities in cable storage ovens, where the water vapor content usually does not exceed 0.03% by volume (less than 1% relative humidity under normal operating conditions). Fig. 4 shows the humidity-measuring cells, as actually installed in the Point Breeze Works of the Western Electric Co. Both the recorder and the constant humidity apparatus for calibrating it have been useful also in the Laboratories in fundamental investigations of the properties of textile insulation under different atmospheric conditions, and similar high-sensitivity apparatus is being used in several universities for scientific investigations.

## PART II—APPARATUS FOR SUPPLYING ATMOSPHERES OF KNOWN ABSOLUTE HUMIDITY

An apparatus which will continuously supply an atmosphere of a constant known humidity, variable at will, was employed in calibrating the above-described sensitive humidity recorder, and in the study of the properties of textile and paper insulation under different atmospheric conditions. The apparatus supplies an atmosphere of constant *absolute* humidity: that is, containing a constant percentage of water vapor by volume. The relative humidity of the supplied atmosphere then depends on the temperature at which it is used.

Briefly, the apparatus provides two streams of air: one thoroughly dried, and the other nearly saturated with water vapor at constant temperature. It then mixes these streams in continuously controlled proportions. The control is exercised roughly by valves where the stream is divided, and precisely by controlling the relative pressure differentials which drive the dry and the moist streams past the mixing point. The functioning of the apparatus in detail can be seen from Fig. 5. Air is taken at high pressure, and the pressure is diminished to a pound or two above atmospheric through reducing valves. This air is then dried very completely by passage at low velocity over a comparatively large surface area of concentrated sulphuric acid contained in a 20-liter carboy B. The acid serves to remove oil impurities as well as water vapor. Part of this air goes through a control valve $V_1$ to a water tower C, contained in the constant-temperature oil bath D, where the air is nearly saturated with water vapor at the temperature of D. The remainder passes through a valve $V_2$ and a flowmeter G, and then is mixed with the humidified air from C, which has been metered through a flowmeter F. The mixture passes to a mixing bottle H, thence through a flowmeter J and a valve $V_3$, and so to the apparatus in which it is desired.

To secure accurate control of the flowing gas mixtures it is essential that the pressures, and pressure differentials, in all parts of the system be constant. Constancy is secured by means of constant-pressure overflow tubes, N, O and P, at essential points. Tube O permits a small amount of the wet air, emerging from the saturator C and trap E, to bubble to waste, and thus compensates for small fluctuations in the pressure. Tube N fulfills the same function for the air supplied to the dry air flowmeter.

This arrangement is well recognized practice in securing relatively constant pressures in flowing gas mixtures, but the addition of a tube P to control the pressure of the mixture is a distinct innovation, and makes it possible to secure remarkably constant control of the compositions of gas mixtures. So long as small amounts of air bubble to waste from these three tubes, the composition of the mixture is fixed. Furthermore, by placing tubes N, O and P in a single bath D, any change in the level of liquid in the bath does not alter the relations between the pressures, and the ultimate composition is unaffected.

These overflow tubes are also used to vary the composition. Their depths below the liquid level in D determine the quantities of air flowing through the several flowmeters: the difference in depth of N and P determines the difference in pressure on the two sides of the flowmeter G, and similarly, the levels of O and P determine the difference in pressure

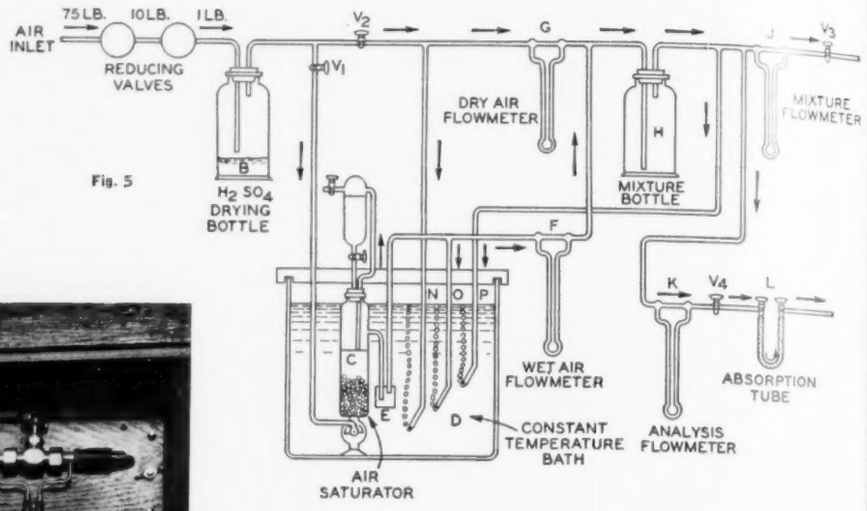


Fig. 5

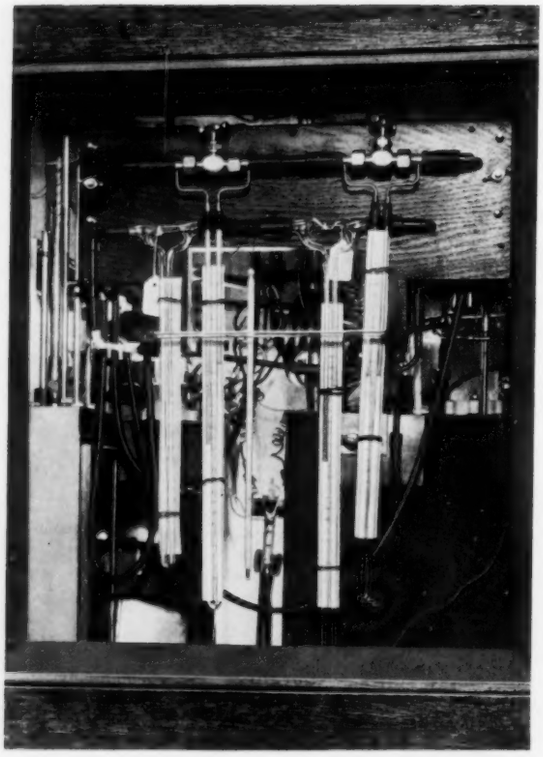

Fig. 6

through F, and thus control the quantities of dry air and wet air, respectively, fixing the composition. Tubes N, O and P are connected to their supply tubes by flexible rubber tubes, and their depths in the bath D may be readily adjusted.

The air passing through C is incompletely saturated due to the expansion of the air bubbles in their passage upwards through the tower. Complete saturation would occur only if the hydrostatic head in C were zero. But by maintaining the water level constant through a continuous automatic siphon, the degree of saturation (about 96%) is fixed with remarkable constancy. Since the temperature of the bath surrounding the saturator is held to within $\pm 0.01°$ C., this constant degree of saturation can be translated as a constant absolute humidity.

The water-vapor content of the delivered mixture may be determined by weighing the amount of water contained in a given volume of the mixture. The apparatus for this determination consists of an accurately calibrated flowmeter K, and chemical absorption tube L, containing "Dehydrite" (magnesium perchlorate-trihydrate). Because of its granular structure, this is much more suitable than the phosphorus pentoxide more generally used, and quite as efficient for absorbing water vapor. The accuracy of a determination depends upon the length of time of absorption required to secure sufficient weight of water, and since the apparatus is capable of giving constant mixtures for many days running, the determination can be made as accurate as desired.

Much of the apparatus is contained in a constant-temperature box with a window for reading the flowmeters (Fig. 6). Fig. 7 is a general view of the apparatus.

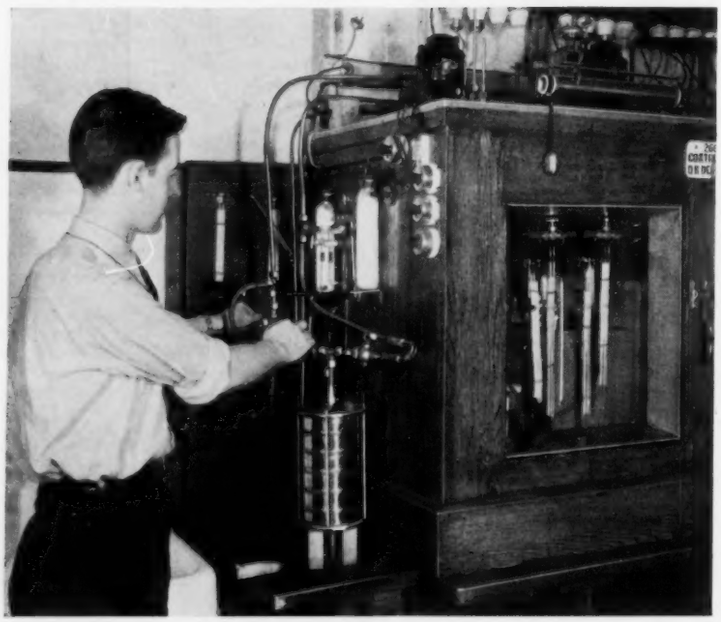

Fig. 7

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## Re Humidity Control Patents

**Lewis Air Conditioners, Inc.**, Minneapolis, Minn., have granted the **Detroit Lubricator Co.**, Detroit, Mich., license under Patent No. 1,785,741, entitled "Air Conditioning Systems."

"This patent contains broad claims relating to any air conditioning system or circuit wherein a humidity regulator is rendered operative by a thermally actuated regulator only when the heating medium has attained a temperature adequate for efficiently evaporating moisture and/or otherwise conditioning the air. The said patent in some of its claims further relates to any air conditioning system where a fan is used for causing air to travel through air conditioning means and where the operation of the fan is controlled by the thermally actuated regulator and rendered operative only when the medium affecting said regulator has attained a predetermined temperature. The said patent covers the hook-up, circuit or system of devices coöperating in the manner set forth in the claims without regard to the specific construction of the individual pieces of mechanism used in that system."

# Fundamental Principles of Orifice Metering

By KENNETH H. WARREN

IF we place in a pipe line an orifice of smaller diameter than the pipe itself, the velocity of the flowing stream will be greater in the orifice than that in the line, because the quantity rate of flow is the same through the orifice as in the line. This means that the kinetic energy of the fluid at the orifice must be greater than it is in the line and, by the Law of Conservation of Energy, the static pressure of the fluid at the orifice must be less than the static pressure of the fluid in the line above the orifice. The result is that a differential pressure or pressure drop is produced across the orifice plate. The magnitude of the pressure drop for any given condition depends directly on the increase of velocity, and therefore on the quantity flowing. The greatest constriction of the fluid is a short distance downstream from the orifice plate. From this point (called the vena contracta) the stream gradually enlarges until it again fills the pipe, and its velocity decreases until it is the same as on the upstream side of the orifice plate; and its pressure increases until most of the pressure drop has been recovered.

A simple flow meter can be made by inserting an orifice plate in the line between a pair of flanges, and connecting pressure taps upstream and downstream from the orifice to the ends of a U-tube. By reading the difference in height of the liquid in the legs of the U-tube, caused by the pressure drop, is is possible to compute the flow by means of an equation. The manometer will not be discussed, but a study of the orifice and of what it does will make it possible to get better and more accurate results in flow measurement. A study of the derivation of the standard commercial formula for gas measurement will give us a better insight into the underlying principles of flow measurement, and, perhaps, point out sources of trouble and inaccuracies in the use of the orifice meter.

In order to get a convenient and practical formula for flow measurement, it is customary to derive the formula from the equation for accelerating bodies (falling bodies):

$$s = \sqrt{2\ g\ h_v}$$

The fundamental principles of orifice meters are the same whatever the fluid be, gas, steam, or liquid. We shall derive the formula for gas measurement, which is the most complicated due to the large number of variables involved. The hydraulic formula is almost universally used in gas measurement although the adiabatic formula may also be used. Use of the latter formula would so involve chart computation as to make it a long and tiresome job. For commercial measurement, therefore, the hydraulic formula has been chosen. It requires several assumptions which are not strictly correct. If all the assumptions made in its derivation were strictly correct, and if all the deviations from its assumptions were separated and corrected factors for each applied, gas coefficients could be computed without experimental data and the hydraulic formula could be used with accurate results under any operating conditions. Much has been done toward isolating these factors but it is undoubtedly safer to determine the total resultant by experiment than to attempt to isolate individual components. The factor, called $E$ in the flow equation, is the experimentally determined ratio of actual to hypothetical flow. Its value remains practically constant for any single ratio of $d/D$ (orifice diameter to pipe diameter), within a reasonable range of operating conditions. The limits, for which the value of $E$ will give commercial accuracy are:

1. Ratio of pipe diameter to orifice diameter ($d/D$) not to exceed .60.
2. On line sizes of 2 in. or more, static pressures greater than atmospheric pressure and a differential pressure greater than 1.0 in.
3. Differential pressure (in. of water) not more than 2 times the absolute static pressure (lbs./in.$^2$).

Now let us proceed directly to the derivation of the commercial formula, starting with our fundamental equation for accelerating bodies:

$$\text{velocity} = s = \sqrt{2\ g\ h_v} \qquad (1)$$

In this equation, $g$ is the acceleration due to gravity (32.16 ft./sec.$^1$) and $s$ is velocity in ft./sec. The symbol, $h_v$, is the height (in feet) of a homogeneous column of the flowing fluid at $P$ and $T_f$, necessary to produce $s$ where $P$ and $T_f$ are the absolute pressure and absolute temperature of the flowing gas. Suppose a column of water to be enclosed in a vertical pipe with an opening at the bottom. The water will emerge from the opening with a velocity directly proportional to the height of the column of water above it. This column is called the differential head or simply differential.

In the case of gas measurement, it would obviously be inconvenient and impractical to measure the differential in feet of gas necessary to produce $s$. Therefore, we have chosen a more practical unit, inches of water at 60° F. Accordingly, we must evaluate $h_v$ in terms more suitable. The weight of a cubic foot of water at 60° F. is 62.37 lbs. The ratio of the height of a homogeneous column of the flowing fluid, in this case gas, to that of an equivalent height of a column of water is $\frac{62.37}{\gamma}$ where $\gamma$ is the density (lbs. per cu. ft.) of the flowing gas. Substituting and dividing by 12 to reduce inches to feet:

$$h_v = \frac{62.37}{\gamma} \times \frac{h}{12}$$

The symbol, $h$, is of course differential in inches of water. Substituting in (1):

$$s = \sqrt{2\ g\ \frac{h}{12}\ \frac{62.37}{\gamma}} \qquad (2)$$

Our density is expressed in lbs. per cu. ft., and, as this is inconvenient for gas measurement, we shall try to find a more suitable way of expressing it. We know that the density of any gas depends on temperature, pressure, its composition. Let $\gamma_a$ = the density of air at 32° F. and 14.7 lbs./in.$^2$, and $G$ the specific gravity of the flowing gas relative to air. Then:

$$\gamma = \gamma_a\ G\ \frac{P}{14.7}\ \frac{492}{T_f}$$

Substituting for $\gamma$:

$$s = \sqrt{2\ g\ \frac{h\ 62.37}{12\ \gamma_a}\ \frac{14.7\ T_f}{492\ PG}} \qquad (3)$$

Introducing our known values, $g = 32.16$ ft./sec.$^{-1}$, $\gamma_a = .08073$ at 32° F. and 14.7 lbs./in.$^2$

$$s = \sqrt{\frac{2 \times 32.16 \times 62.37 \times 14.7 \times h\, T_f}{12 \times .08073 \times 492\, PG}} \qquad (4)$$

Note that all we have derived so far is a rate formula (ft. per sec.) and that ultimately we want a formula for volume. Let Q = volume in cu. ft. per hr., then multiplying by the time factor and by area to obtain volume:

$$Q = sA \times \text{time or } Q = s\left(\frac{\pi d^2}{4 \times 144}\right) 3600 \qquad (5)$$

We multiplied by 3600 because $s$ is expressed in ft. per sec. and Q is expressed in cu. ft. per hr. We multiplied by the area of the stream at the point of measurement to get volume. In order to tie down the cubic foot to a specific quantity we must introduce 2 other factors, $P_B$ and $T_B$, which are the pressure and temperature at which the gas is to be stored or considered to be measured at. In other words, we must convert the quantity of gas from flowing conditions to basic or storage conditions. This we do with the aid of Charles' and Boyle's laws:

$$Q = \frac{P\, T_B}{P_B\, T_f} s\left(\frac{3600\ \pi d^2}{4 \times 144}\right) \qquad (6)$$

Substituting for $s$:—

$$Q = \frac{P\, T_B}{P_B\, T_f}\sqrt{\frac{2 \times 32.16 \times 62.37 \times 14.7 \times h\, T_f}{12 \times .08073 \times 492\, PG}}\left(\frac{3600\pi d^2}{4 \times 144}\right) \qquad (7)$$

Simplifying and cancelling $\sqrt{\frac{T_B}{P}}$

$$Q = 218.44\, d^2\, \frac{T_B}{P_B}\sqrt{\frac{h\, P}{T_f\, G}} \qquad (8)$$

Now if we insert the additional factor $E$ in our formula, it assumes the form of the familiar commercial formula:

$$Q = 218.44\, E\, d^2\, \frac{T_B}{P_B}\sqrt{\frac{h\, P}{T_f\, G}} \qquad (9)$$

Why do we use the value $E$? Because in deriving the above formula from the hydraulic formula, we were forced to make several assumptions that were not strictly correct. This factor $E$ compensates for all the inaccuracies in a derivation from the hydraulic equation as long as the conditions of measurement are similar to those under which the original value was determined. The value of $E$ has been determined experimentally. What assumptions did we make in deriving the above formula? They are listed below:

1. The area of the flowing stream at the plane of the downstream pressure tap (flange connections) is the same as that of the orifice.
2. The velocity of the gas approaching the orifice is negligible.
3. The density of the gas remains constant.
4. The flow of the gas is stream-line and without friction.
5. There is no deviation from Boyle's law.

By maintaining the foregoing operating limits, any of the deviations from the above assumptions, not compensated for by the value of $E$, are kept down to negligible quantities.

The upstream edge of the orifice plate is sharp and square. The gas in passing over it moves inward toward the center of the pipe causing a contraction of the flowing stream at the downstream pressure tap (taps at the flanges). This most important deviation is taken care of by the value $E$. This contraction continues to maximum point (vena contracta) and then gradually increases in area until it is halted by the pipe wall. When connections other than at the flanges are used, the $E$ value naturally is different and the conditions under which the value of $E$ was computed must be duplicated for the measurement of the fluid. (The most universally used distances for the upstream and downstream pressure taps are at the flanges, or 2½ pipe diameters upstream and 8 pipe diameters downstream.)

The gas moving through the orifice has an initial velocity which we have neglected in deriving our formula. We might readily have taken care of this by introducing another factor in our formula, but, since this would have needlessly complicated our formula, we have taken care of this, also, in the value of $E$. (This initial velocity is termed the velocity of approach.)

We assumed that the density of the gas remained constant in passing through the orifice. Gas is compressible and if the pressure changes, the density must change also, unless a compensating change in temperature occurs. It has been proved by experiment that the total correction is so small, at ordinary commercial pressure ratios of differential to static pressure, as to be negligible. (Note again the foregoing limits for commercial accuracy.)

If proper care has been used in the selection of the pipe for the meter installation, particularly on the upstream side, and the fittings do not obstruct the gas flow, we can safely neglect the effect of friction.

Most of the flowing temperatures of commercial gases will range from 50° to 70° F. under all year conditions. From experimental data collected by the Bureau of Standards, the fact has been substantiated that there is no wide deviation from Boyle's law at ordinary temperatures and pressures. Obviously, with very high pressures or low temperatures it would be necessary to make a correction to our total quantity of gas, but, since these rarely occur in commercial measurement, we are not forced to add another correction factor to our standard commercial formula.

It is hoped that, in the above discussion and development of our standard formula, a better understanding of the principles underlying measurement with the orifice meter has been reached. In such a short sketch as this, it is impossible to do much more than outline the basis of commercial measurement. It is advisable, therefore, to devote further study to the proper installation, care and maintenance of orifice meters, so that they will function properly and accurately, within the operating limits recommended by the manufacturer.

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## Research Seminar

IN addition to its evening courses in chemistry, Rutgers University is offering a 12-session conference course beginning in mid-October. A group of research chemists, chemical engineers, etc., will be formed and the members will divide reading assignments and report on the material they have covered. Outside lecturers include the editor of *Instruments*. It is expected that the major part of this Seminar will deal with optical methods and modern uses of instruments. Readers within 2 or 3 hours of New Brunswick are invited to communicate with Ass't Director M. A. Chaffee, Extension Division, Rutgers University. Some conferences may be held in industrial plants in northern New Jersey.

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## U. S. Firm to Build World's Second-largest Telescope

Contract for the design and construction of the new McDonald Observatory on Mt. Locke in southwestern Texas, containing the second largest telescope in the world, has been awarded to the Warner & Swasey Co., Cleveland. The telescope is to be of the reflector type, approximately 26 feet long, with a main mirror 80" in diameter, weighing 5000 lbs. It will be housed in a three-story observatory, 71 feet high, surmounted by a dome weighing 115 tons.

# Flow Measurement and Control*

By M. F. BEHAR†

## CHAPTER XXIII—POSITIVE METERS

### POSITIVE GAS METERS

**10. Bellows Meters**

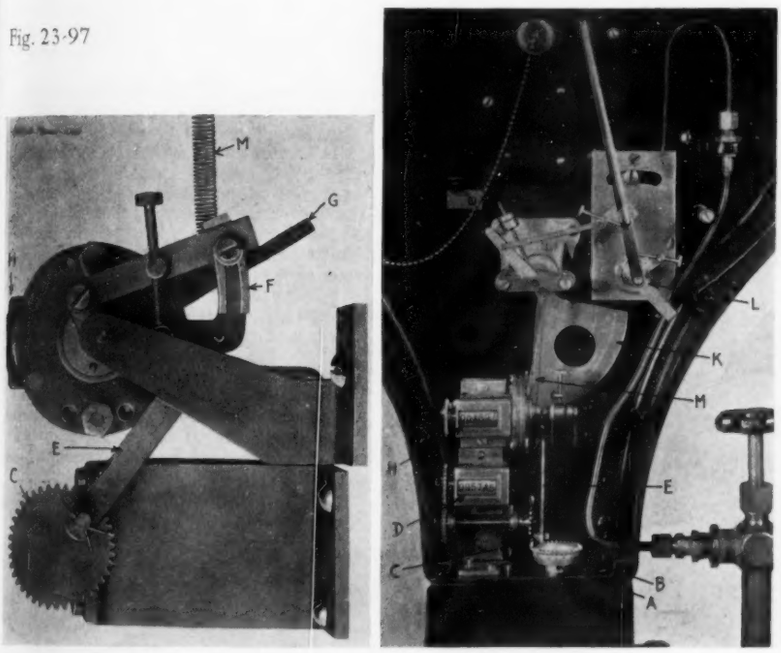
**(i) Auxiliary Instruments**

*Pressure Instruments*

(*Continued*)

Converting actual cubic feet to standard pressure-base cubic feet by applying the proper pressure factor can be done automatically by interposing between the meter shaft and the register a pressure-actuated device somewhat similar to a variable-speed drive, of which the speed ratio depends, at every instant or for successive increments, on the line pressure and on the specified pressure base. In practice, though, there is not interposed a variable-*speed* drive but an intermittent conjugation drive whereby each cycle of integration consists of two parts: one during which the meter is connected to and drives the base pressure counter and one during which there is no mechanical engage-

Fig. 23-97




Drive shaft A is driven directly from the meter and through crown gears B and C operates counter D, which registers actual cubic feet of gas at meter pressure. (A proving scale is stamped on gear B to facilitate accurate calibration of the meter.) Gear C, by means of link arm E, causes segment F to oscillate for each revolution of gear C. Segment F picks up and moves arm G, which through an accurate ball clutch ratchet, operates corrected-reading register H. The magnitude of the angular movement of arm G governs the reading of H and this angular movement is limited in its back stroke by the position of pressure cam K, which is directly connected to pressure element L. Spring M maintains arm G in contact with segment F when the arm is not in contact with pressure cam K. Thus, the amount through which the reading of H is advanced is dependent on the position of cam K which depends directly on the metering pressure.

Pressure element L is calibrated with the cam in place. The contour of the lower edge of the cam determines the base pressure to which correction is made and recorded on the totalizing counter or index. The cam is so shaped that at all points the angular movement of operating arm G is proportioned to Boyle's Law. Due to the fact that natural gas deviates appreciably from Boyle's Law at pressures in excess of 50 lb per sq. in., special adjustment can be incorporated for natural gas metering.

*Part Six of *The Manual of Instrumentation.*
†Editor, *Instruments.*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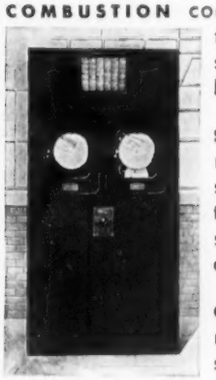

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**FEED WATER** regulators for feed water to steam boilers.

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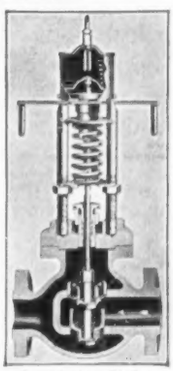

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# MANUFACTURERS' LITERATURE

**In this department we each month list the printed matter issued by manufacturers. Unless otherwise noted, any of the items listed may be secured free upon application to the issuing firm. Manufacturers who have not yet sent in their printed matter are invited to do so.**

A255 **Relays.** 4-page Bulletin R-33 describes new features of "1933 Standard Relays" with 18 contact arrangement diagrams. Signal Engineering & Mfg. Co., New York City.

A256 **Valve Handbook.** 264-page Catalog 23 is an extraordinarily exhaustive source of information on valves and valve layout. The last section contains engineering data needed where valves are used. Jenkins Bros., New York City.

A257 **Pressure Controllers.** 24-page Bulletin No. 2000-c, describes construction and operation of compensated pressure control instruments; explains control valve compensator, said to eliminate hunting, "cycling" and overcontrol; also parabolic gradual opening ball-bearing control valve. Mason-Neilan Regulator Co., Boston, Mass.

A258 **Noise Measurement.** Reprint of a 5-page article in The Review of Scientific Instruments. E. E. Free Laboratories, New York City.

A259 **Control Valves.** 4-page Bulletin No. 933 describes 2-, 3- and 4-way, multi-port and distributing valves and their uses. W. H. Nicholson & Co., Wilkes-Barre, Pa.

A260 **Pitometer System.** 16-page Bulletin 16 on water distribution studies and trunk main surveys; 24-page Bulletin 17 on water waste surveys; 24-page Bulletin 14 on primary elements and indicating and recording (pen and photographic) instruments; 32-page Bulletin 10 on directions for installation and operation. The Pitometer Co., New York City.

A261 **Telescope.** Leaflet on new riflemen's spotting scopes. Bausch & Lomb Optical Co., Rochester, N. Y.

A262 **Solenoid Valves.** June 1933 edition of loose-leaf catalog of Asco solenoid valves for automatic and remote control. Automatic Switch Co., New York City.

A263 **Magnetic Switches and Relays.** 20-page Bulletin 900 (1933 edition) contains technical data. Automatic Switch Co., New York City.

A264 **Electric Control Valves.** 12-page Bulletin 203A is illustrated with refrigerating plant application diagrams; 4-page Bulletin 201A discusses valve controls. Frick Co., Inc., Waynesboro, Pa.

A265 **Humidistat.** Leaflet describes new contact-type humidity controller. Texair Instrument Co., New York City.

A266 **Optical Instruments** for the Metal Working Industries. 48-page catalog presents detailed descriptions. Bausch & Lomb Optical Co., Rochester, N. Y.

A267 **Photoelectric Relays.** 16-page Bulletin GEA-1654A describes latest types and discusses applications. General Electric Co., Schenectady, N. Y.

A268 **Recorders.** Folder describes features of new recording thermometers and pressure gages. The Brown Instrument Co., Philadelphia.

## INSTRUMENTS, 330 W. 42nd St. New York City

**Please have me supplied with a copy of each piece of Manufacturers' Literature listed below.**

.....

.....

Name.....

Position.....

Firm.....

Street and No.....

City ..... .....State.....

ment. The time period of each complete "on-and-off" cycle is immaterial. It depends on the actual volume passed through the meter: for instance it may represent 100 actual cu. ft.; but the *ratio* of "on" to "off" in each cycle depends on the pressure: the higher the pressure, the higher this ratio. For example, in an instrument designed for a base pressure of exactly 15 lb (abs.) and for an installation where the line pressure will not exceed 150 lb abs., the gearing would be such that the corrected-volume counter would be driven at ten times the speed of the actual-volume register but only when it is in engagement. Should line pressure be 150 lb abs., the engagement would be continuous; at 75 lb abs. the ratio of "on" to "off" would be exactly 50-50; and at 15 lb abs. this ratio would be 1 to 9, causing the corrected-reading register to increase its reading by 10 cu. ft. as would an ordinary actual-volume register—which of course it should do when the line pressure is equal to the base pressure.

Such, in brief, is the principle of operation employed both in the "Emcorector" (Pittsburgh Equitable Meter Co.) and in the "Metric" Base Pressure Index (American Meter Co.), although they differ in mechanical details. The Emcorector, Fig. 23-97, is mounted directly on top of a meter in place of an ordinary register and it is provided with two cyclometer counters—one which registers actual cubic feet passed through the meter, and one which registers cubic feet at base pressure. It is available in three models: one with a recorder similar to the Wylie Pressure and Volume Gage; one with a recorder similar to the Emco Combined Record Gage; and one that does not provide chart records. The Metric Base Pressure Index, Fig. 23-98, likewise mounted on top of a meter in place of the customary register, is ordinarily furnished with one counter which gives corrected volume, but may be furnished with a supplementary counter giving also the actual volumetric reading. Any type of volume and pressure gage supplied by the American Meter Co., can be installed on top of the Base Pressure Index without need of special tools.

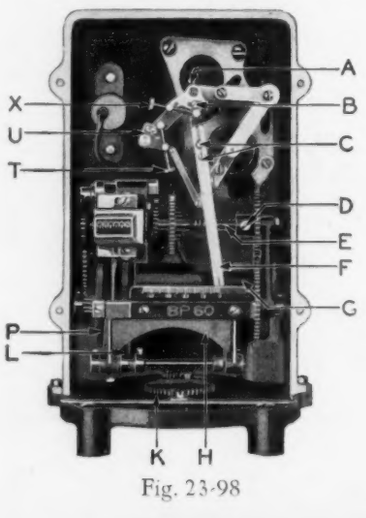

Fig. 23-98

Gear $K_1$ driven by the drive shaft of the meter register, makes one revolution for each 10 cu. ft. of actual volume through meter at meter pressure. (A proving pointer on K facilitates accurate calibration of the meter.) Shaft E, driven from K through 1:10 gearing, revolves once per 100 actual cu. ft. and in turn drives the actual-volume register (on back of instrument—not visible in this view) and cylindrical cam G. The cam contour is such that the arc of the raised cam surface increases in proportion to the reading on the pressure scale in front of it. Pressure indicating arm F, by its position along G, thus determines the duration that a train of gears is in mesh during each revolution of G, and the ratio of this duration to the complete revolution is the same as the ratio of the absolute base pressure to the absolute meter pressure. In each cycle of integration, therefore, the reading of the corrected-volume register is advanced by an increment that is equal to 100 cu. ft. times the absolute line pressure divided by the base pressure for which the cam was shaped.

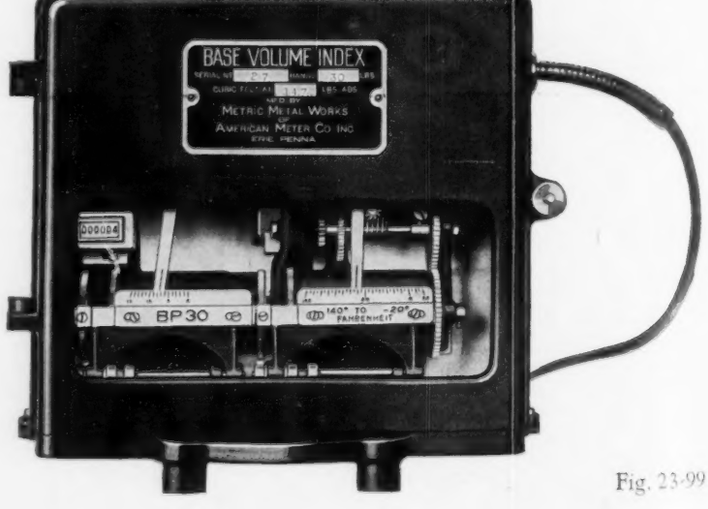

Fig. 23-99

*Temperature Instruments*

In various industrial processes the temperature of the gas to be measured by a positive meter may differ so much from the 60° F. base that it becomes necessary to correct for Charles' Law. Where the temperature is fairly constant, an indicating thermometer suffices, and is read twice or four times a day. To minimize labor and dependence on human factors, recording thermometers are preferable for industrial process applications. Where the metered volume is large, or the metered gas expensive, so that the utmost accuracy is desired, an automatic device becomes necessary. The principle is similar to that of the automatic pressure instruments dealt with in the preceding paragraph: the position of the "pointer" of a thermal system determines the conjugation period ratio of a gear train in each cycle of integration. The "Metric" Base Volume Index (American Meter Co.), Fig. 23-99, is a combination instrument with two integrating mechanisms, one governed by a pressure-measuring element and one governed by a temperature-measuring element. Each integration is intermittent as described above. The combination provides final registrations in cubic feet at standard conditions of base temperature and base pressure—that is to say, the true *quantity* or *weight* of gas.

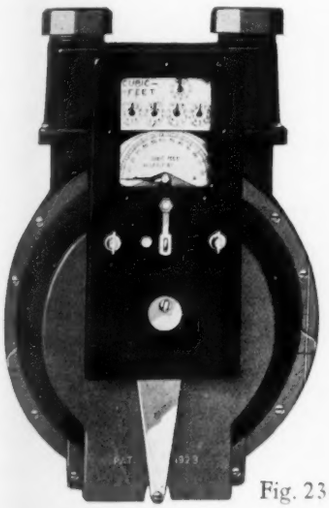

Fig. 23-100

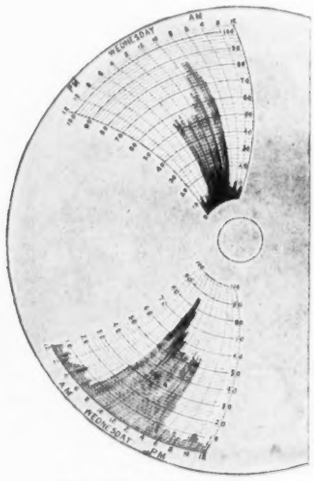

Fig. 23-101

*Demand Devices*

Suppose that two departments, A, and B, in a plant consume each 24,000 cu. ft. a day, and that A uses up this quantity during an eight-hour period while B uses 1000 cu. ft. per hour. It is evident that the supply equipment required by A will have to be designed for 3,000 cu. ft. per hour. Therefore, A should be charged more than B on the books of the plant.

Demand attachments and demand meters furnish data a study of which often leads to considerable economies. There are two general types: the indicating and the recording, to which may be added the totalizing relay.

*Indicating.* A maximum-demand device, or an indicating demand meter, simply indicates the maximum volume passed during any 15-, 30- or 60-minute period. A spring-driven or electric clock releases the mechanism at 15-, 30- or 60-minute intervals, so that the pointer advances only when the timed volume exceeds the previous high reading. The pointer remains at the maximum-demand indication until returned to zero by hand, which, if desired, can only be done after opening a lock or breaking seals. Fig. 23-100 shows an indicating demand device (8-day clockwork) attached to a No. 3 cast iron meter of the Sprague Meter Co.

*Recording.* Not to be confused with rate-of-flow recorders, recording demand meters provide records which do not show the instantaneous load but consist of (1) a series of radial traces corresponding to the volumes passed in successive periods of 15, 30 or 60 minutes, or (2) a series of marks all alike and representing each a definite volume.

(1) For the principle employed in this the usual type of demand recorder see Fig. 23-72. In brief, the pen or stylus advances in proportion to the revolutions of the meter register, being driven by the meter, and drops back to zero at the end of each time interval. For bellows meters this type of demand recorder is generally of the seven-day round-chart form, and usually the meter manufacturer offers the choice of "standard" or "reverse" charts. In "reverse" charts the zero is at the outer edge, making it easier to read the time-of-day


WET TEST

METERS

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**INDICATOR**

*Dial-type Flow Indicator*

**Dial and Mercury column types...These Indicators are applicable for indication of flow-rates of water, oils, chemicals, air, gas and steam under wide range of conditions.**

**Maximum W.P.–Dial type..... 250 lbs.**
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**Both types used with MJL Orifice and Flanges...*Write for complete literature.***

**MOREY & JONES, Ltd.**
***Manufacturing Engineers***
**923 So. Hemlock St., Los Angeles, Cal.**

# INSTRUMENTS BOOK SHELF

**Photometric Standards (Encyclopédie Photométrique, 3e Section—Photométrie Visuelle, Tome II—Etalons Photométriques).** By PIERRE FLEURY. Editions de la Revue Optique Théorique et Instrumentale, Paris, 1932. Cloth, 6x9 inches, 122 pages. Price 25 francs.

Comprising as it does one of the 27 volumes in the great encyclopædia of photometry being prepared by a group of French physicists under Charles Fabry, this little book deals only with the specific subject of standards for measurements of visible light. We note, however, that in addition to detailed descriptions of various standards, some of their uses in other branches of photometry and in kindred sciences are briefly mentioned. This is not an instance of padding out, inasmuch as the encyclopædia includes volumes on optical pyrometry, colorimetry and other sciences outside of the field of photometry proper. The reader who expects to find Fleury pulling out of a silk hat a definite, convenient, easily reproducible standard will be disappointed, and the worker who desires further acquaintance with the formidable difficulties surrounding the development of such standards will find them discussed candidly by the author as the result of his years of research, so that he (the reader) will not agree perhaps with Charles Fabry's unqualified declaration—in the Preface—that "the future solution will certainly take the form of a primary standard based on the employment of a definite radiator (very probably, a black body) heated to a definite temperature." The reviewer, for one, after reading through Fleury's book, inclines to the belief that the future primary standard will be "cold"—which belief may spring from the mere wish for a standard source that does *not* have to be raised to the temperature of freezing platinum at which the luminous intensity cannot be maintained constant without extremely close control of the temperature. As for Fleury's poor opinion of carbon filament sources, it seems unjust in the light (no pun intended) of their successful use as working standards at the (U. S.) Bureau of Standards where they permit photometric measurements accurate to 0.25%. At any rate, it will probably be years before we have a standard which fully meets the exacting requirements detailed in Chapter I.

This first chapter opens with the author's "specifications" and then reviews the various sources successively employed since the birth of photometry for the determination of the "candle." Chapter II discusses and compares flame standards; Chapter III does the same for filament standards and Chapter IV reviews the attempts to use a platinum surface or an electric arc. In the fifth and last chapter Fleury takes up black body standards, adds a recent communication from the (U.S.) Bureau of Standards on the latest platinum standard, and concludes with a personal statement recommending the international unification of photometric units.—M. F. BÉHAR

**(7)-B-Regulators (Kontrol- und Regulier-einrichtungen).** By M. JAKOB, P. GMELIN and J. KRONERT. Akademische Verlagsgesellschaft, Leipsig, 1932. Cloth 6½x9½ inches, 208 pages. Price 18.60 marks.

This is Part 1 of Vol. II of Der Chemie Ingenieur—an extensive manual of physical methods in chemical and allied industries, being prepared under the direction of M. Eucken and M. Jakob. The latter is apparently the editor of the present volume, the actual writing of which seems to have been done by Herren Gmelin and Kronert. In his Foreword, the illustrious Fritz Haber declares that students of chemical engineering in the German Hochschule have not been getting enough instruction in (or acquaintance with) applied physics and actual equipment; and that the present work therefore stands midway between a theoretical text and a catalog-like handbook.

Chapter 1 (11 pages) outlines the field of industrial instruments; Chapter

(Continued on Page A5)

of the majority of individual traces. Fig. 23-101 (American Meter Co.) is a comparison of these two styles.

(2) The "Maryland Type" of recording demand device or meter embodies a drum which not only rotates but also advances axially, taking seven days to complete a run. The record is a spiral, as on a cylinder phonograph, and the chart when laid flat shows slanting lines. The demand record consists of small marks produced by a fountain pen oscillated by the meter mechanism. Thus the demand for any hour, or half-hour, or other period, is determined by counting these marks and multiplying by a constant.

*Totalizing Relay.* This type of device is meeting with favor in large industrial plants where there are batteries of meters. It permits the use of one demand recorder for the entire battery. It should be used only for a battery of meters all of which are the same size and type, so that the cubic foot value of the electrical impulses from all meters will be the same. Each meter in the

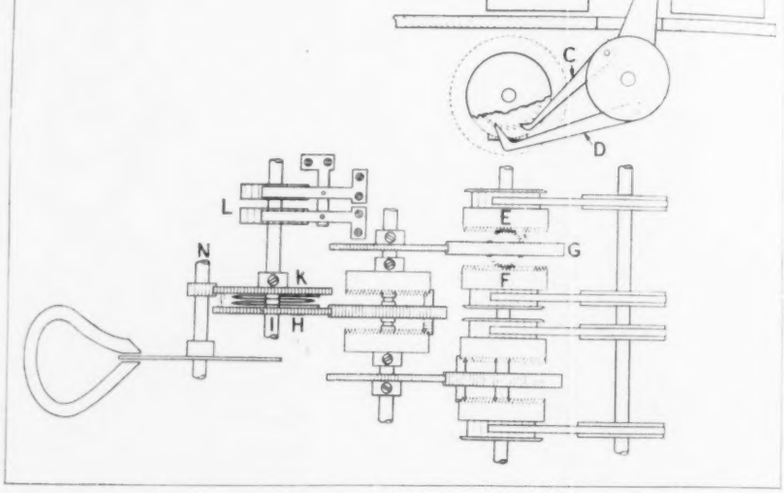


Fig. 23-102

battery is equipped with a pair of mercury switches actuated by the flag rod. Fig. 23-102 (American Meter Co.) is a schematic diagram of a four-unit relay. Four sets of solenoids, indicated by *A* and *B*, controlled from a three-wire circuit, operate pawls connected to crown wheels *E* and *F* which are parts of the differential mechanism. The impulses received from these solenoids are transmitted to ring gear *G*, which rotates an amount equivalent to the summation of the rotations of crown wheels *E* and *F*. The movement is then transmitted to another gear which is also one side of a second differential train. This second differential sums up the advances made by the two initial differentials and transmits this motion to gear *H* which is mounted loosely on contact shaft *I*. Gear *H* is connected by means of a coil spring to gear *K* mounted rigidly on the contact shaft and located definitely with respect to *H* by two small contact pins which are held together by means of a definite tension in the spring. After gear *H* is advanced, its pin moves ahead of the pin mounted on gear *K*, and the spring, then being free to act, moves gear *K* ahead until its pin stops against the pin on gear *H*. This motion in gear *K* is transmitted to the contact shaft which rotates the contact cams *L* and transmits the proper number of impulses through the three-wire circuit to the demand device.

It will be seen that shaft *N*, carrying a disk running between the poles of the drag magnet, is geared to shaft *I*, the action of the drag magnet slowing up the motion of the shaft so that the impulses from the three-wire circuits are transmitted to the demand device at a rate slow enough to be recorded by the demand device mechanism. Thus, if impulses were received simultaneously on four sets of solenoids, and assuming a "contact ratio" of 1 to 1, gear *H* would be advanced four contacts ahead of gear *K*. Gear *K*, however, would rotate shaft *I* at a speed determined by the drag magnet so that, although the four impulses were received at the same instant, they would be transmitted to the demand device slowly and individually through the three-wire contact mechanism.

# NEW INSTRUMENTS

**Write Information Section, Instruments Publishing Company, for additional information.**

## Portable Oscillograph

### By Kirk A. Oplinger*

DESIGNED for acoustical studies, measurements of vibrations, accelerations and pressures, and applications relating to industrial uses of vacuum tubes as well as radio broadcasting, this entirely new self-contained oscillograph may be used as conveniently as an ordinary voltmeter or ammeter. Overall dimensions are 8″x11½″x11″ and total weight is 18 lbs. Operation is from 110-volt 60-cycle circuit without auxiliary attachments. At the lower left and right hand corners of the top panel (see Fig. 1) are located the terminals for the two galvanometers, both of which may be used for measurements of potentials up to 300 volts or currents up to 10 amps. without external resistors. In the upper left hand corner are the two zero adjustment knobs. The "timing" knob at the

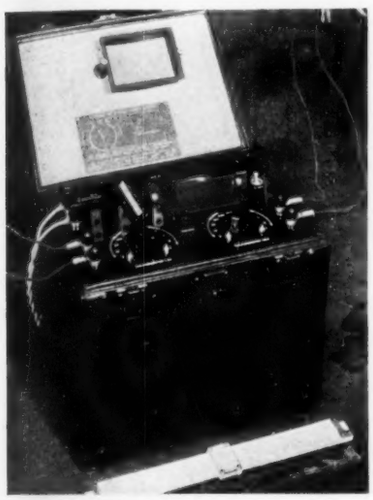

Fig. 1

upper right corner varies the timing axis to control the number of cycles visible on the viewing screen. Both film and screen are stationary and in position for use at all times, so that when it is desired to take a photograph it is only necessary to press the "expose" button near the center of the panel.

Simultaneous viewing and photographing is made possible by the novel optical system, Fig. 2, which also gives the equivalent of a long optical lever in a small space. The number of faces on the revolving mirror, and the angles subtended by the film and viewing screen, have been so chosen that there always is a light spot entering on both the film and screen just as the preceding spot is leaving. A spherical lens above the viewing screen gives enough brilliancy for viewing even in daylight. Viewing lens and screen may be replaced by large curved screen in lid (see Fig. 1) to permit tracing wave form and for demonstrating before a group of students.

*Research laboratories, Westinghouse Elec. & Mfg. Co.

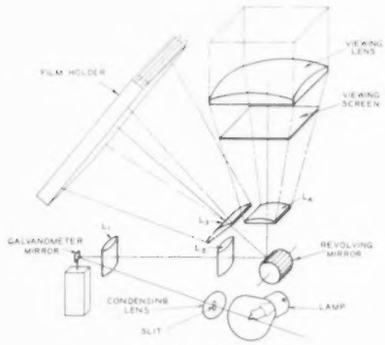


Fig. 2

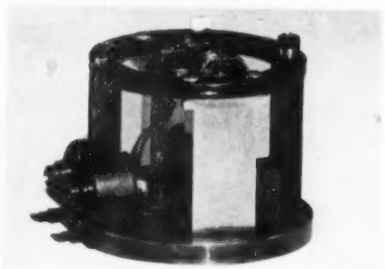

Fig. 3

The galvanometers are of a new type—moving iron with balanced armature as suggested by C. R. Hanna before the I.R.E. in 1925. Fig. 3 shows one in actual size. Cobalt steel permanent magnets supply steady flux in the four air gaps. When current flows in the coils, the flux in one pair of diagonally opposed gaps is increased while the flux in the other pair is decreased, resulting in a force couple tending to rotate the armature. The restoring force is furnished by the armature support which is of novel construction. The mirror, mounted above the armature, has 15 times the area of an ordinary oscillograph galvanometer mirror, and yet the armature remains steady in its gap and the sensitivity (for 5 kc. response) is 0.1 amp. d.c. per inch deflection. Electromagnetic damping is independent of temperature and the frequency response characteristic is more satisfactory than with oil damping. The circuit devised in order to use a single galvanometer for both current and voltage measurements, makes the galvanometer response independent of external circuit resistance and also provides a simple arrangement for making tap connections on the shunt and multiplier resistors.

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## Control Power Unit

### Minneapolis-Honeywell Regulator Co.

NEWEST of a series of all-electric motor power units designed to provide mechanical motion in true proportion to the demands of temperature or pressure controllers, the Type M94-2 Modutrol Motor offers a practical means of obtaining true modulation of heat, cold, humidity or air flow. It is actuated by potentiometer (slide contact and resistance wire) controllers available for control of room temperatures, duct temperature, liquid containers and pressure. The motor arm rotates through 160°, or 80° either side of mid-position; its throw is adjustable from a minimum radius of $1\frac{5}{32}$″ to a maximum of $2\frac{1}{16}$″. It may be set at intervals of 22½° throughout a complete circle. The recommended maximum load for Modutrols with 120 seconds timing is 14 lbs., for 180 seconds timing 18 lbs., and for 240 seconds timing 25 lbs.

There is no flattering or hunting in the operation. A demand for a slight increase or decrease in heat causes the motor arm to take up a new position in proportion to the heat demand, and the motor stops until more or less heat is again demanded by the thermostat or controller. Other characteristics: Available for 50 to 60 cycle a. c. current only. May be mounted in any position except with motor shaft upright. Mounting plate may be screwed to the bottom, on either side or at one end of the Modutrol case. Internal connection block for wiring connections. Provision for conduit connection at top of case. Current consumption: Running 15 watts, standby 8 to 11 watts.

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## New Clip-on Ammeters

### Ferranti, Inc.

IN appearance these resemble the dual-range standard model (*Instruments*, Feb. 1932, page 54) but they can be furnished with single or dual ranges in any combination from 7.5 to 1000 amps., the first point on the scale in each model being 10% of full range. The lower range Clip-On Ammeters are slightly more expensive due to the use of a precision instrument. However, the current consumed by small motors, etc., can thus be accurately determined. As before, a plush-lined solid leather carrying case with lock and key, and with shoulder strap, can be supplied. Any of the Clip-On Ammeters can be placed around an insulated or uninsulated conductor leading to a motor, transformer, etc., and the current can be safely and quickly measured without shutting down the load or disconnecting the circuit.

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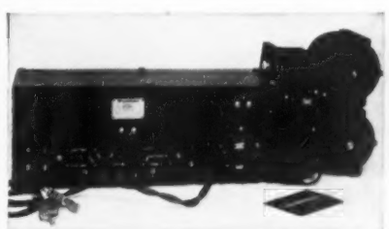
## Automatic Oscillographs

### Westinghouse Elec. & Mfg. Co.

WITH the recent addition of a new positive or negative sequence current network initiating panel, the Westinghouse automatic oscillograph can now take care of all

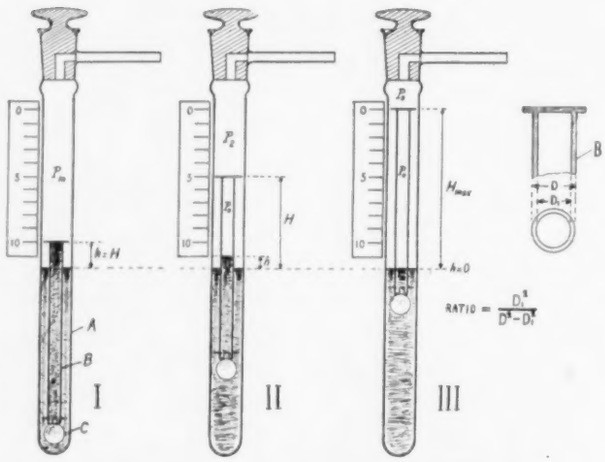


fault conditions on any one feeder. New resistance control units extend the laboratory range of the equipment. Externally adjustable twin galvanometers allow the beam to be placed on the film as in the conventional manner. New fuses give positive protection for the usual voltage supplies found in laboratories. In each unit are 13 conveniently ranged steps of sufficient current capacity to take care of the entire vibrator line. A new film holder (optional) takes 200 feet of sensitized paper. Film can be cut off in any length desired.

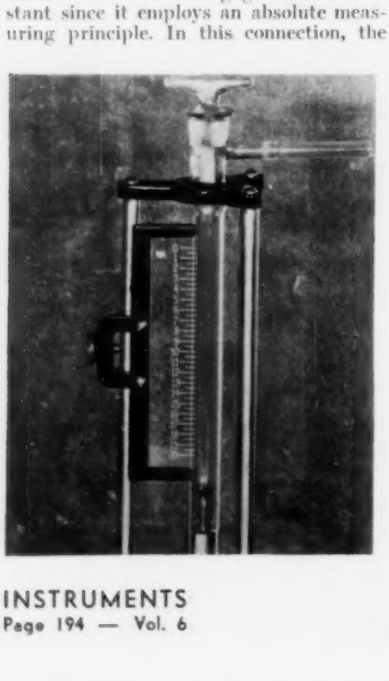
## New Type of Vacuum Gage

**John Dubrovin**

AN entirely new principle is employed in this mercurial gage, distinguishing it from the U-tube type, from the barometer type and from the compression (McLeod) type although it is akin to all three. It also resembles the inverted-bell type but with the difference that the space under the bell does not communicate with the vacuum vessel under measurement. The Dubrovin gage consists of a cylindrical glass vessel *A* partially filled with mercury, in which floats metal tube *B* resting on hollow glass sphere *C*. The top of *B* is closed and it is exhausted; both ends are provided with prongs to keep it concentric with *A* while allowing it to move vertically. The upper end forms the indicating element of the gage, traveling alongside a graduated scale.




The system *BC* floats at all times. The height *H* of the indicator, therefore, is an inverse function of the height *h* of mercury inside *B*. This height *h* is a measure of the absolute pressure being measured and its limit, of course, is reached when *B* is completely filled with mercury as shown in diagram I. This maximum *h* is determined by the constants of the individual instrument, as is the maximum value of *H* with no pressure in *A* or in *B* (see diagram III). Thus $(H_{max} - H)$, is a function of the absolute pressure $P_2$ and the relation is linear by reason of the uniformity of the diameter ratios, assured by precision manufacturing. Likewise, the amplification factor of any gage is determined by its constants, *i. e.*, by fixed dimensions. The meniscus effect and the temperature coefficient are negligible in the commercial models with amplification factors of 6 or 9. Furthermore, the calibration of a Dubrovin gage remains constant since it employs an absolute measuring principle. In this connection, the most important precaution in use is to avoid contaminating the mercury and altering its specific gravity—which is true of all mercurial pressure instruments. Production has begun on two commercial models, each scaled from vacuum to 20 mm. Hg, one approx. 16" high with a 6x scale, the other approx. 23" high with a 9x scale.



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## Oil Sediment Indicator

**Electronic Inspection Labs.**

RAPID determinations of the concentration of opaque impurities in crankcase oil (and other liquids) are made with this new portable photometer of the turbidity meter or opacimeter type. The "Electronic Oil Sediment Meter" embodies a dry-disk photocell directly connected to a microammeter; a light-source adjustable to constant voltage provided by batteries; and a sample-holding slide formed of two parallel polished lenses with separator glasses maintaining a film 0.0065" thick. To make a test, a few drops of clean oil (from a bottle in the outfit—see illustration) are placed on the slide, which is inserted in the housing, automatically switching on the lamp when fixed aperture through lens housing is properly positioned between lamp and photocell. The rheostat is adjusted so that the microammeter reads "100." The slide is removed and wiped clean; a few drops of oil from the "bayonet" are placed on it; it is again inserted and the microammeter is again read, its indication being an inverse function of the concentration of sediment. The film being 0.0065" thick, the "color" of the oil causes only a trifling error: if the rheostat is adjusted to give a reading of 100 with "Nujol" (or water), the reading for a *clean* sample of the darkest cylinder oil will not be less than 96%; thus unscrupulous service station men cannot "fix" the apparatus. On the other hand, the instrument is by virtue of its principle extremely sensitive to opaque content: for example, in measuring the colloidal graphite content of a well-known lubricant, in thousandths of 1%, the variance was 3%, *i.e.*, an error of 0.00003% in terms of colloidal graphite content.

The new device can be used as an opacimeter by inserting paper samples in the oil slides; also as a continuous turbidity meter by flowing the liquid through a special chamber which replaces the oil slide.

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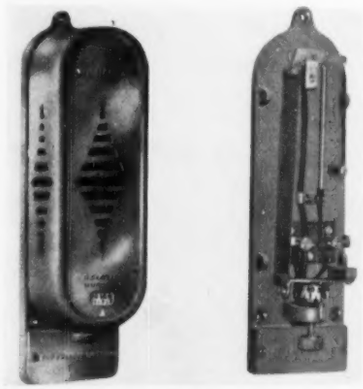
## New Humidistat

**Texair Instrument Co.**

SENSITIVE enough to cut-in and cut-out within a 1% differential in relative humidity, this new humidistat was developed for operating humidifying and de-humidifying apparatus as a 2-wire or a 3-wire controller. It is said that the ribbon type sensitive element has no tendency to drift and is unaffected by temperature changes up to 200°F. Range is 20% to 100% relative humidity. Base is cast aluminum, cover is pressed steel, finish is old gold lacquer (others optional). Rating is 10 watts at 110 volts with a 100% reserve. Contact arms are equipped with platinum-iridium oversize points. Binding posts are concealed behind plate removable from front without disturbing case cover, conforming to Underwriters' rules.



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## Photoelectric Kit

**Weston Electrical Instrument Corp.**

BROUGHT out especially for those engineers and manufacturers who prefer to do their own experimenting with photoelectric control for operations and processes of various kinds, the new Photronic Control Kit contains all the equipment necessary to start experiments, together with diagrams of connections. The equipment can be used as a smoke detector, burglar alarm, turbidity detector, door opener, counter, safety device on machines, etc. The cell included in the Kit is the Weston Pho-

tronic Cell which transforms light energy directly into electrical energy and operates the Weston relays without the use of any auxiliary apparatus or batteries. As far as is known, the cell has unlimited life and the output is constant. Its spectral response is about the same as that of the human eye, so that it is sensitive to color changes.

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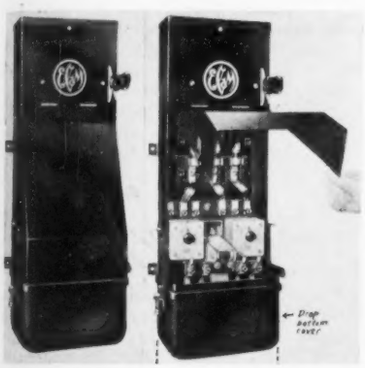
## Industrial Motor Starter

### The Electric Controller & Mfg. Co.

FOR motors up to 15 h.p., 220 volts, and 30 h.p., 440-550 volts, there is announced Type ZOS oil-immersed, across-the-line, combination magnetic starter, containing an unfused or fusible safety switch, a magnetic starter with overload relays, and heavy-duty test jacks for applications where it is desired to insert meters in the motor circuit without interrupting the operation of the machine. All internal wiring is complete. Although designed for mill duty, these starters are small and narrow, suitable for mounting in restricted spaces such as between the flanges of columns, or for closely grouping many starters along a wall. Sturdy construction is used throughout. Safety switches have wiping wedge, double-break contacts, heavy gage steel parts with all actuating parts case-hardened. Magnetic



starters are quiet in operation and have bushed arm bearings, larger-than-average clearances between live parts and high arc-rupturing capacity. Overload relays provide sensitive overload protection and have high heat inertia to withstand heavy overloads.

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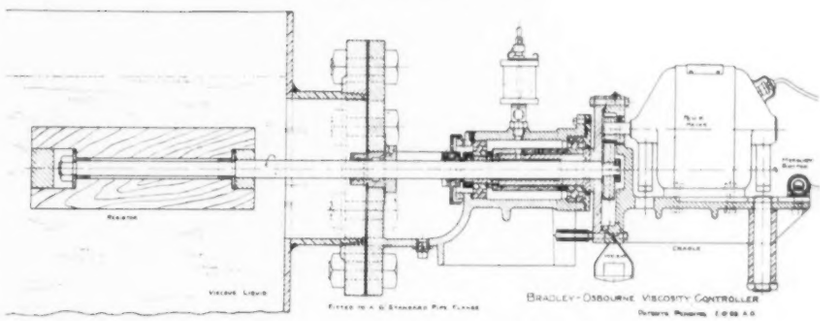
## Lightning-bolt Ammeter

### General Electric Co.

EASILY attached to transmission towers, a new instrument is making possible more extensive measurements of lightning current (frequently >25000 amp.) and also makes it possible to determine the polarity of these currents. The method is extremely simple: Small pieces of magnetic material, called magnetic links, are mounted on brackets and installed within a few inches of one leg of the transmission tower. A stroke of lightning passing through the transmission tower magnetizes the link in proportion to the highest value of current in the lightning discharge. Line patrolmen remove magnetized links and turn them over to the power company engineers. The magnetized links, when placed in a surge-crest ammeter, cause the pointer to indicate the highest value of current in the lightning discharge.

## Automatic Control of Viscosity

### Thyle Machinery Corp.




IN processing lubricating oil, paper pulp, lacquer, varnish, catsup, condensed milk, rayon, borax sludge, chocolate and other viscous products, variations in the consistency of the liquid often give trouble. This device regulates viscosity automatically by governing the rate of feed of water or other constituent of a mixture, in accordance with the viscous drag on a resistor running at exactly 690 r.p.m. (or some other constant speed which has been pre-determined). Essentially, the device is a dynamometer and the viscosity is measured by the inclination of the cradle-supported $\frac{1}{6}$ h.p. motor and reduction gear (see diagram). The motor housing thus serves both as an "indicating pointer" and as a pilot-actuator. Its range of swing is adjusted in each installation by adding or subtracting weights in a counterweight-pan connected to the motor base by a steel tape. The motor housing actuates a mercury switch, operates a pump-control needle-valve, sounds an alarm, flashes a light or performs any other signalling or controlling function.

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## Multi-Range Test Set

### Ferranti, Inc.

VOLTAGES from 0.5 to 600 volts, and currents from 50 ma. to 5 amps. can be accurately measured by means of this new test set designed for use on frequencies from 25 to 100 cycles, and suitable for d.c. use at only a slight reduction in accuracy. The set

consists of a voltmeter and ammeter, $2\frac{1}{2}$" dial, 110° scale, moving iron meters mounted in a black molded case with hinged cover, containing conversion table, etc. The voltmeter has six ranges: 0-7.5, 15 and 30 volts, 10 ohms per volt, and 0-150, 300 and 600 volts, 100 ohms per volt. The ammeter has two ranges: 0-0.5 and 0-5 amps. Both instruments are of the repulsion type, having irons of nickel-iron alloy treated to minimize errors due to iron loss, hysteresis, etc. Torque is high for this type, and damping excellent. Option: solid leather carrying case with lock and key, and with extension strap for shoulder use. The whole outfit weighs only $1\frac{3}{4}$ lb. Overall dimensions without case, $5\frac{1}{2}$"x$4\frac{3}{8}$"x$2\frac{1}{4}$".

## The Variac

### General Radio Co.

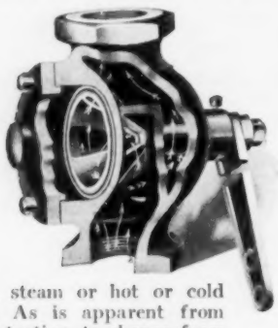
GIVING a.-c. voltage control with the smoothness of a rheostat and the efficiency of a transformer, this novel power transformer provides continuous voltage adjustment between 0 and 130 volts when operated from a 115-volt, 60-cycle line. Its applications in laboratory and the industrial fields include: (1) laboratory source of adjustable voltage, (2) speed control on small motors, (3) over-voltage and under-voltage testing on electrical appliances of all kinds. A contact mechanism eliminates short-circuited turns which heretofore made a continuously adjustable tapped transformer an impractical device. There are two models: Type 200-CM has a protecting case, an attachment cord, and an outlet receptacle and is intended for laboratory and experimental use; another model, without the case, is for

those who wish to build the Variac into other equipment. Maximum current rating is 5 amps. Models for larger and for smaller currents are under development.

## Chronometer Valves

### Defender Automatic Regulator Co.

SUITABLE for operation by hand or by automatic devices, these newly-announced "Improved Fitts Type" adjustable re-grinding chronometer valves are said to be the longest-lived for reg-



ulating steam or hot or cold liquids. As is apparent from the illustration, to change from open to closed or vice versa requires only a 45° displacement of the lever. This lever is adjustable as to its position with regard to the conical head and stem (which are cast in one piece), and the head itself may be tightened or loosened to adjust properly for the physical properties of the controlled medium. The illustration shows a small size valve, of semi-balanced construction; there also is a yoke type so fully balanced that it can be operated by a low-powered device (such as a float) thereby making close control readily attainable. This "perfect balance" is obtained in these yoke type valves by means of a micrometric set screw which can be adjusted until the head just "rides" on the seat without friction. Naturally, such valves are not designed for complete shut-off. Materials of stock valves are bronze, cast iron or cast Cr-Ni alloy steel. Sizes range from ½" to 4".

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## Motorized Pilot Valve

### Baldwin-Southwark Corp.

FOR the present the only standard application of this valve is the Stress-Strain Recorder-Controller (*Instruments*, April 1933, pages 90-91) in which it plays an important part in the automatic control of rate-of-strain, rate-of-stress and constant-load applications. It should find uses in connection with industrial process control systems. The valve proper (1) may be seen in Fig. 1; its operating mechanism shows up better in the top view, Fig. 2. Operation is as follows: Contacts (in the measuring in-

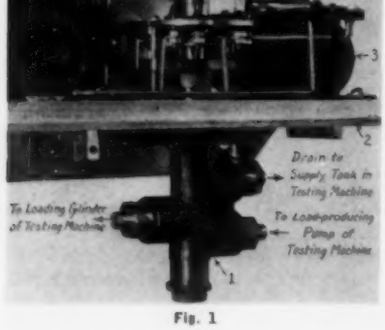


Fig. 1

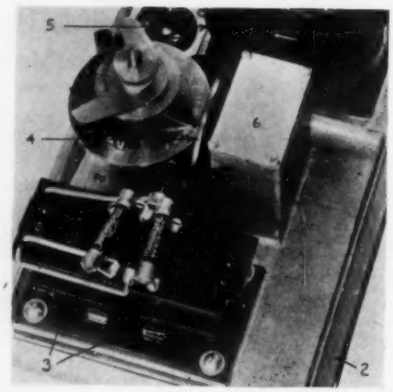


Fig. 2

strument) are so arranged as to cause the energizing of one or the other of the two solenoids (3) through the usual sensitive relay. Current for these services—both for the relay and for the solenoid—is supplied from a d.c. source, either storage battery or rectifier unit. The sole-

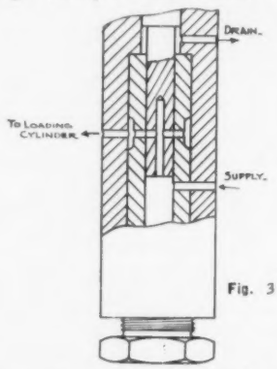


Fig. 3

noid armature is attached to the end of a shaft carrying two fine-tooth bevel pinions, neither of which in mid-position of the shaft engages bevel gear (4). This gear (4) runs continuously, being driven by motor (5) through worm reduction (6). Any energization of a solenoid causes engagement of one or the other of the bevel pinions with the bevel gear and a rotary motion is transmitted to the valve stem. This motion opens or closes a port in the valve in such a way as to reduce or as to increase the quantity of oil entering the power cylinder. Fig. 3 is a diagrammatic section of valve (1).

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## Tubular Rheostats

### Ward Leonard Electric Co.

DESIGNED for the accurate control of currents up to 25 amp., these new sliding contact tubular rheostats (laboratory type) are arranged for potentiometer connection and may be obtained with non-inductive or tapered resistance windings. The three lengths (8", 16" and 20") cover a wide range of resistance values. A feature of the

new design is a single point, silver contact. Rheostats equipped with micrometer drive are provided with a clutch which readily permits single hand adjustment of slider. Escapement at ends of drive shaft prevents straining assembly when slider reaches end of travel.

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## Pocket Stroboscope

### F. Ducasse & Son

SHOWN here three-fifths of actual size, the "Strobo-Meca" weighs 10½ oz. It is of the "slit" or interrupted line-of-sight type and is driven by a spring motor. The operator holds the instrument to his eye with one hand,

and for long observations he uses his other hand to re-wind the motor by means of the finger-sprocket stem. Available in three r.p.m. ranges: 500-8,000; 1,000-12,000; 1,000-16,000. Usual limit of error when used as a stroboscopic tachometer is 1%, and accuracy may be checked by observing a watch.

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## Grille Type Microphones

### The Brush Development Co.

IN these novel microphones, each sound-cell is an extremely small piezo-electric microphone with an active surface less than ¼ in.², so small that it causes a minimum distortion of the wave front. Any number may be combined into a single microphone according to the output required. When this is done, the sound-cells, in the form of a *grille*, are enclosed in a metal cage allowing the sound to pass completely through the microphone, without cavity resonance or reflection. The response is flat on open circuit to 6,000 cycles, increasing from 6,000 to 10,000 cycles by about 4 db.

*Output Level*—On 25 feet average cable:

—2S2P microphone:—74 db.
—4S6P microphone:—68 db.

*Impedance* of single sound-cell similar to a capacity of 0.0033 mf. Sound-cells are usually series-paralleled so that the capacity will never be less than this value. D.c. resistance should be over 5 megohms. Capacity of leads has very little effect on the high frequency response of the instrument because the sound-cells themselves present a capacity load or negative reactance. All of these microphones are normally designed for operation directly into grid of the first tube of the preamplifier. A grid leak of about 5 megohms should be used. Brush grille-type microphones, with the exception of types H and D, have the advantage of being non-directional and consequently extremely sensitive. Care should be taken to exclude all extraneous noise. When used for sound reinforcing, the loud-

speakers should be placed as far from the microphone as possible to prevent "feed-back." Likewise, the microphone should be as near the source of sound as possible.

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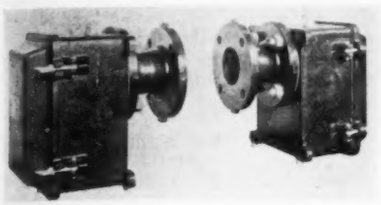
## Smoke Density Recorder

### General Electric Co.

PHOTOELECTRIC equipment for indicating and recording the degree of density of smoke passing through the stacks or breechings of power and heating plants, has been announced. The essential elements are a light source and a photoelectric relay unit designed for mounting on opposite sides of the stack. As the smoke density increases, the phototube receives less light from the source



and the instrument indicates or records the increase of smoke. Lenses are provided in front of the phototube and light source. Clean air is drawn by the induced draft of the stack across the lenses, which assists in keeping them clean. The lenses require some cleaning, however, and therefore the apparatus has been designed so that the lenses are easily accessible. An adjustable electrical contact for operating an alarm circuit is provided which can be adjusted to any point between 20 to 60% of full smoke density. Adjustment can be made by the use of a screwdriver. The recording instrument is optional.

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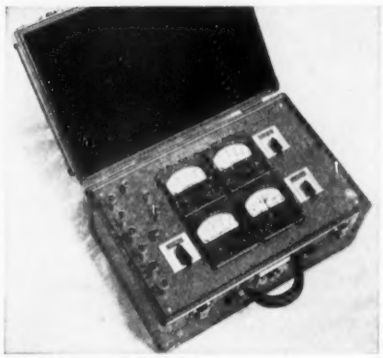
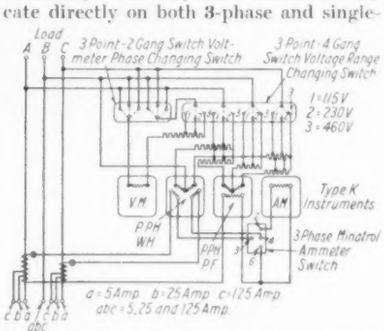
## Portable Testing Set

### Westinghouse Elec. & Mfg. Co.

CAPABLE of making complete tests of a.-c. apparatus and motors up to 100 h.p., the Industrial Analyzer is a miniature portable 3-phase switchboard panel in a carrying case complete with all necessary switching equipment, transformers, and resistors. It contains a triple-scale ammeter 0-5, 0-25, and 0-125 amps., a triple-range voltmeter 0-150, 0-300, and 0-600 volts, a polyphase wattmeter with three scales for these voltage and current ranges, and a polyphase power factor meter with 10-100-80 scale to operate on these voltages and currents. The instruments are the new low-burden miniature Type K (*Instruments*, June 1933, page 129) with scales 3½" long. Two special lightweight current transformers with Hipernik cores and with primary winding tapped for 5, 25, and 125 amps. are connected into the circuit in the conventional 3-phase wiring scheme to provide the multiple current ranges. The various voltage ranges are obtained by switching tapped resistors in the potential circuits. By means of the Minatrol switch, the ammeter may be switched under load to any one of the three phases to determine load balance. 3-phase and single-phase motors and other apparatus may be tested and checked by connecting the Analyzer to the line at the fuse clips, junction box or terminals and connecting the out-



going terminals to the load. Single phase testing is accomplished by connecting line and load to terminals A and B and setting the ammeter to read line A current and voltmeter to AB voltage. The ammeter, voltmeter, and wattmeter indicate directly on both 3-phase and single-




phase circuits. The power factor motor being of the polyphase type does not indicate correctly single phase power factor.

Carrying case measures 7x11x19". Appearance and arrangement have been given considerable study. Total weight is 28 lbs. Accuracy is to within 2%. The outfit should prove useful to service men, trouble shooters, plant maintenance, layout and efficiency men, electrical dealers, etc.

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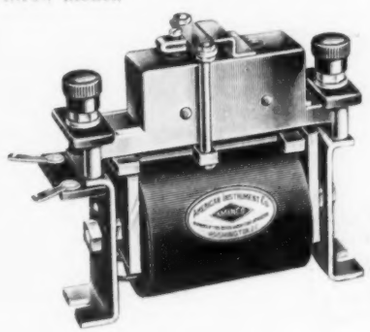
## Supersensitive Relay

### American Instrument Co.

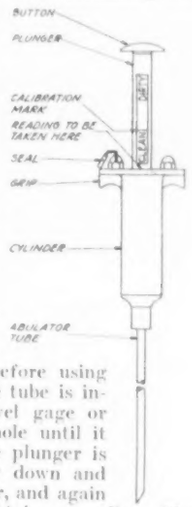
AN operating current of 5.4 ma. at 6 volts d.c. (or 0.032 watt) and a contact rating of 1100 watts, give this new supersensitive relay the high relaying ratio of 34,000:1. The high coil resistance makes it suitable for use with vacuum-tube relay circuits. Its small size fits it for many types of equipment such as thermo-regulators, etc. Overall dimensions are 3⅝ x3½" x 1¾". Coil rating: 1100 ohms; 5.4 amp. at 6 volts. Contact rating: 10 amp. at 110 volts, or 5 amp. at 220 volts, a c.; available in normally open, normally closed, or single pole, double throw model.



## Crankcase Dirt Indicator

### Clardon Corp.

SUBSTITUTING a quantitative determination for the "finger and thumb" method of ascertaining the amount of solid particles in crankcase oil is the purpose of this new device, designated as the "Abu'ator Gage." It is said to be as easy to use as a tire pressure gage, except that the readings take a long time when the oil is cold. This inconvenience disappears, however, when the motor has been warmed up. The motor must be stopped before using the instrument. The tube is inserted into the level gage or filler or breather hole until it reaches the oil; the plunger is pushed all the way down and released to expel air, and again pushed down to obtain a reading. The plunger rises at a diminishing speed and finally stops, exposing more or less of the scale which simply consists, in the model illustrated, of the words CLEAN and DIRTY with a mark between. If the plunger rises enough to expose a part of the word CLEAN, the oil is safe for further use. If it stops before exposing the "calibration" mark, the oil contains too great a proportion of foreign matter to be safe for further use.

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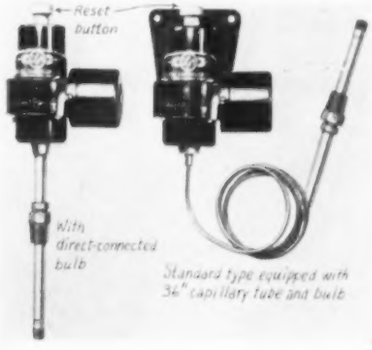
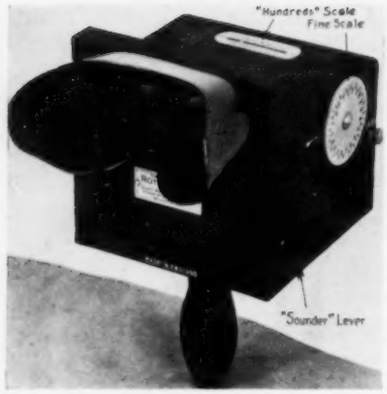
## Bearing Thermal Relays

### The Electric Controller & Mfg. Co.

FOR protecting against breakdowns due to overheated bearings, these thermostats are suited for use in connection with automatic pumping stations, motor-driven fans, substations, conveyors, compressors, etc. The EC&M Leaflet 1120 Bearing Thermostat consists of a bulb containing a volatile liquid and connected, directly or through flexible copper tubing, to a one-piece seamless metal bellows which operates silver contacts of double break, quick make and quick break construction. Factory-set to operate at 212°F., it can be adjusted in the field to operate above or below this value. Proper operation is obtained with the bulb or relay installed in any position. Contacts can be connected so that they will not only stop the rotating equipment but sound an alarm or flash a signal.






## "Type C" Stroboscope

### Livingston & Southard

EXTREME accuracy when used as a tachometer is obtained in this new model of the Rotoscope by means of a precision speed governor, a scale which can be read to 1 r.p.m., and a unique means whereby the instrument can be standardized conveniently. This last feature is a "sounder" producing 120 clicks per minute. To check the primary speed, a little lever is moved, causing the clicks to become audible, and their cadence is then easily checked against the second hand of a standard timepiece. If necessary, the primary speed is regulated by turning the "fast and slow" adjustment. With care, the primary speed should not differ from the standard by more than 0.05%, which then will be the limit of intrinsic error —actually less than errors of observation in reading the fine scale.

The sight gear is the unique "bladed shutter" giving better definition than would a slotted disk 10 ft. in diameter. Speed range of standard model is 800 to 6000 glimpses per minute, permitting observing mechanisms at 12,000 and under favorable conditions at 18,000 or 24,000 cycles or revolutions. Other ranges available. Weighing hardly more than a pair of powerful field glasses, the Model C can be used for hours without fatigue. The phonograph type spring motor, clockwork and sight gear are said to be of the highest workmanship: "mercury hardened steel pivots running in ring sapphires," etc.

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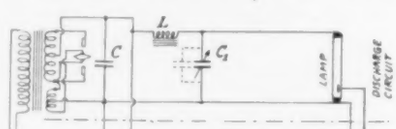
## Mercury Lamp Stroboscope

### Int'l Broadcasting Equipment Co.

EMPLOYING three "281" tubes which can be bought in any radio store and a mercury lamp stocked by the maker, the new "Type 180" stroboscope is said to be a practical device for the plant. Definition is sharp enough to permit reading a newspaper wrapped around a drum rotating at a peripheral speed of "well above a mile a minute." The outfit consists of a main housing 29½" x 10" x 8" equipped with carrying handles, a mercury lamp, and a contactor mechanism with synchronous motor and variable-speed drive. Operation (refer to circuit diagram) is as follows: Large reservoir condenser C, connected across the output circuit of the full-wave rectifier system, charges condenser $C_1$ to a potential of approximately 700 volts through reactor L. $C_1$ is in turn connected across the two discharge electrodes of a 3-electrode mercury lamp. Owing to the high initial resistance of the lamp, no discharge of $C_1$ is possible at 700 volts until the surface resistance of the mercury pool is broken down. To this end an auxiliary flashing circuit is used, consisting of a Tesla coil with its primary condenser $C_2$, a motor-driven variable-speed contactor, and the third electrode of the lamp. Condenser C serves also to charge $C_2$, which, in turn, is discharged through the primary of the Tesla coil by means of the contactor. At the instant of discharge a secondary voltage high enough to break down the surface resistance of the mercury pool in the lamp is applied between the anode and the third electrode. This lowers the




resistance between the discharge electrodes and permits $C_1$ to discharge through the lamp, which then delivers a brilliant flash of short duration, both the brilliancy and duration being directly dependent upon the value of $C_1$, which is made variable to adjust the operation of the instrument to suit the immediate requirements of speed and degree of illumination. As soon as $C_1$ is discharged, the lamp is extinguished and choke L permits a re-charge of the condenser. The presence of some type of lag circuit such as reactor L is required, as this removes the possibility of a continuous discharge from condenser C resulting in either an unduly prolonged flash or continuous illumination.

At speeds above 1800 r.p.m. the contactor mechanism should be driven from the same shaft or mechanism as the device under observation.

For photographic purposes the mercury lamp has the proper actinic value and an additional capacity may be added across $C_1$ to get the necessary high degree of illumination.

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## Stroboscopic Tachometer

### F. Ducasse & Son

ESSENTIALLY of the interrupted-light type, this portable instrument may also be used as an interrupted line-of-sight stroboscope. At the rear is a powerful electric lamp surrounded by a slotted rotating cylinder and by a fixed outer cylinder with two apertures. In daylight or bright artificial illumination, observations are made by sighting through the cylinders at the rear; normally, the lamp is turned on and its interrupted beam is thrown onto the mechanism to be observed. The rotating cylinder is a compound-sleeve arrangement, permitting adjustment of number and width of slits in order to regulate definition or illumination as circumstances may require. The main housing contains a universal motor, a variable-speed drive and a Jaeger chronometric tachometer. The "M.D.D. Stroboscope" is available in three r.p.m. ranges: 0-7000; 0-10,000; 0-14,000; each being multipliable by 2, 3 or 4 when number of slits is correspondingly altered. The graduations on the Jaeger tachometer start at zero but the M.D.D. outfit, as a stroboscope, is not recommended for frequencies below 750 per minute.

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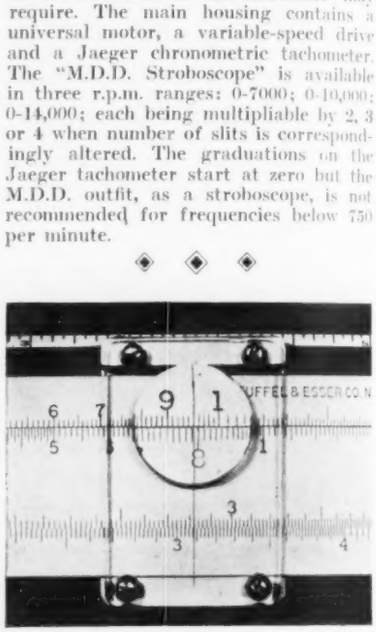


## Slide Rule Magnifier

### The Slip-lens Co.

SHOWN here in actual size, the "Slip-lens" fits any slide rule, magnifies approx. 2×, is applied by slightly wetting bottom and laying on "same as a postage stamp," slides from one scale to the other and stays on rule indefinitely.

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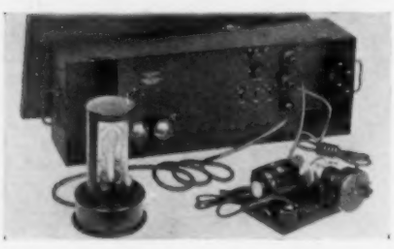
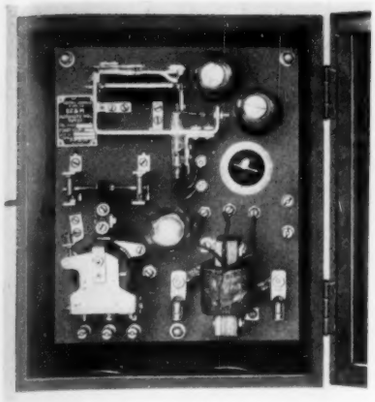
## Automatic Weld Timer

### The Electric Controller & Mfg. Co.

FOR use in connection with resistance welding machines, this timer does not provide a definite amount of time for each weld, but varies the time automatically in inverse proportion to the rate of current flow. When the Automatic Weld Timer is properly installed and adjusted for the range of work at hand, it is claimed that each weld will be perfect and that all welds will be uniform regardless of fluctuations in line voltage, condition of electrodes, variations in thickness of material, amount of rust, dirt, scale, etc. The original adjustment is made by welding a few scrap pieces of the work to be done and then these





welds are torn apart for inspection. When the desired weld is obtained, the cabinet door may be locked and for all practical purposes within reasonable limitations, it will not be necessary to readjust the timer. For the exceptional case, however, the adjusting dial can be changed to suit the particular condition. The standard type (illustrated) consists of a rectifier tube which charges a fixed condenser in proportion to the rate of current flowing in the welding circuit. When the charge reaches an amount sufficient to pass current through two neon tubes, a small relay is operated which, in turn, opens the relay controlling the main line contactor. The tubes are in the circuit only when the welding current is on, so that as soon as the main welding circuit is opened, the weld timer is ready for the next operation.

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## Tensile Strength Tester

### Amthor Testing Instrument Co., Inc.

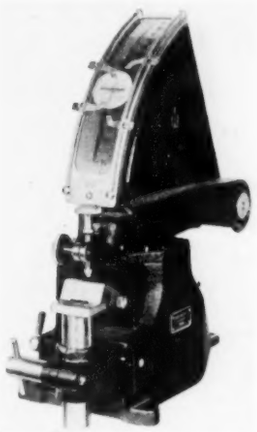
AUTOMATIC operation minimizes human errors in the use of this new 1500-lb. pendulum type testing machine, designated as Horizontal Type 275. The specimen having been inserted, the "start" button is pressed and the test completes itself without further attention. When the specimen breaks, the maximum indication remains on the

hand-calibrated dial; the motor stops and the pendulum arm returns to its next test position. The machine has two capacities, so that it may be used also as a sensitive tester of light materials. Clamps may be set at various distances and may be supplied for a wide variety of cable and sheet materials. Either an Elongation Indicator or an Autographic Recorder may be had.

## "Microlux" Comparators

### Marburg Bros., Inc.

RAPID handling of inspected parts is made possible by this new line of mirror comparators, because (1) there is no dependence on the user's sense of feel, (2) the part being tested is compared with both the high and low tolerance limits at one setting, (3) the result is seen at a glance, (4) the indication is a dark line across a circular illuminated area, and (5) the user does



not have to shift his glance and re-focus his eyes. It is said that rapid and accurate inspection is now made possible "by unskilled labor." Accuracy is assured by a magnification of 1000, and among the various models are some which do permit any unskilled user to be assigned on inspection work. The distinctive feature of this line, common to all models, is the fan-shaped top part containing the 1000:1 optical lever. A steel contact ball and a steel anvil are standard equipment, but a spherical diamond and a Widia-insert anvil may be supplied. Many auxiliary parts, such as arbors, contact rollers, etc., can be furnished in connection with the model illustrated, and there are numerous special models, including a thread comparator designed solely for inspecting external threads in large quantities.

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## Photographic Flowmeter

### The Trimount Instrument Co.

SIMPLICITY characterizes this newest flow instrument and is attained by the operating principle roughly shown in Fig. 1. The differential pro-

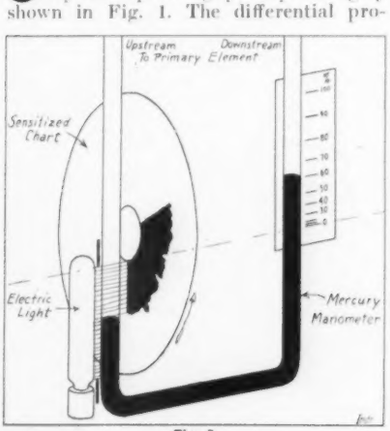


Fig. 1

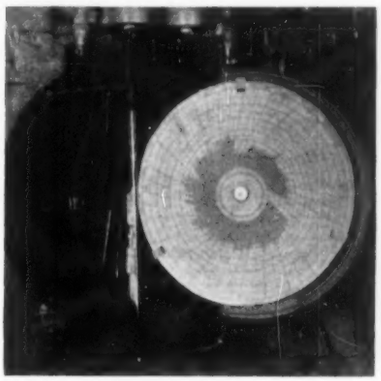

Fig. 2

duced by an orifice or other primary metering element is measured by a mercury-in-glass U-tube manometer. One leg is used as the indicator; the other obturates more or less of an adjacent line-source of light, thus recording on a sensitized paper chart. Fig. 2 is a "Foto-Flo Meter" with cover swung open to show the arrangement. The light source is a specially-designed lamp of unusually long service-life. The U-tube is tested to withstand 2½ times the operating pressure. Each recorder is provided with "special patented" seals to keep the U-tube clean. A by-pass valve and a scale-setting thumbscrew make zeroing so easy that "each operator is his own service man." Fresh charts are mailed monthly (in envelopes containing 31) to each user—an automatic supply system said to be welcomed.

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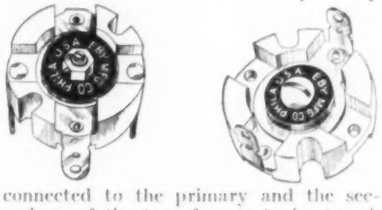
## New Radio Devices

### H. H. Eby Mfg. Co., Inc.

#### 1. TRIMMING CONDENSERS

THESE are available in single or double assembly. The single assembly can be used in the intermediate frequency transformer and adjusted from one side for each condenser which is respectively

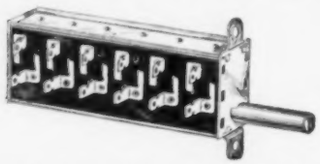


connected to the primary and the secondary of the transformer to be tuned. It is said that electrostatic coupling arrangements, never before provided in condensers of this character, are made practical. The condensers are usable separately or in sets in connection with intermediate frequency transformer assemblies, etc. They are mounted easily and the design compensates for mechanical error in the assembly with which it is to be used. The base is made of high grade ceramic material with a power factor of between 0.4 and 0.5%. The single or double assembly can be made in any practical range, the low range being 10 to 80 Mmf and the high range 700 to 1000 Mmf.

#### 2. MULTI-POLAR ROTARY SWITCHES

APPLICABLE to the new circuit requirements and built to fit into restricted space, these new switches are for equipment or apparatus requiring one to six poles, either single or double throw where low capacitance

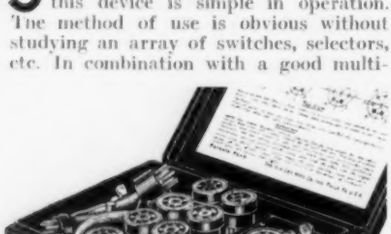
between live parts and ground is essential. Suggested uses: (1) Two-band radio receivers; (2) Universal radio receivers, as change over switch from a.c. to d.c.; (3) Low powered transmitters,



where low capacitance is essential; (4) Test equipment; (5) Laboratory apparatus; (6) Signalling systems; (7) Electronic equipment. Among features are: All steel corrosion-proof frame, phenolic materials for insulation, phosphor bronze double contacts—silver-plated—low contact resistance.

### 3. UNIVERSAL ANALYZER ADAPTOR

SAID to be "the first really constructive contribution to the service field," this device is simple in operation. The method of use is obvious without studying an array of switches, selectors, etc. In combination with a good multi-



range meter it performs all the functions of the modern analyzer or tube checker and is not restricted to any circuit or tube limitations. Arranged for point-to-point tests, circuit break-in tests for checking voltage or current to any element or for short circuits between elements of any tube having up to seven base prongs and cap contact, this Adaptor is not made obsolete in the event that a new tube with additional prongs, elements, internal connections or special arrangements for new uses is presented to the market.

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## Photoelectric Opacimeter

**By John W. Forrest***

SIMPLY defined, opacity is the property which prevents printing on the page behind from showing through. It is expressed as "contrast ratio" or "printing opacity." In the measurement of contrast ratio the paper is backed successively by a block of magnesium carbonate and by a black body. The second reflection value divided by the first gives a decimal known as contrast ratio. In the measurement of printing opacity there is substituted for the magnesium carbonate block, a number of sheets of the sample, the number being such that the addition of more will not alter the reading. Readings are made under this condition and when a single sheet of the sample is backed by the black body. The ratio obtained by this method is known as printing opacity. Neither of these two values is the equivalent of a transmission measurement of the sample. Of the two ratios, printing opacity approaches most nearly to reading conditions where one has the printed page backed by other pages of the same material upon which are letters or cuts.

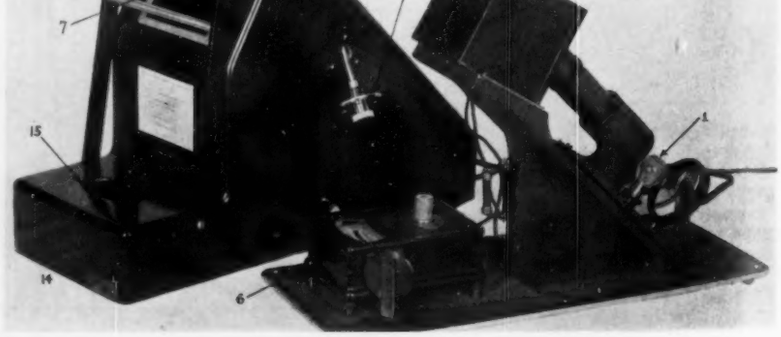
Visual instruments for making such measurements, while performing in correct manner, are slow to manipulate and require a number of readings to secure the desired accuracy. The new photoelectric opacimeter, originally made and tested by Dr. M. N. Davis, Research Physicist for the Kimberly Clark Corp., of Wisconsin, consists essentially of an illumination system and a receptor system. The first provides a strong constant illumination which is projected upon the sample to be measured. The second measures the amount of light reflected from the sample under a rigidly established set of conditions. The illuminant is a 32 c p. 6 volt auto headlight bulb (1). This source is imaged approximately in a small circular diaphragm which is in turn imaged upon the sample aperture (3). A variable diaphragm in the projection system gives control of the amount of light falling upon the sample. The receptor system consists of an integrating cube (4), essentially an enclosed unobstructed space, its inner walls painted with white diffusing material (Bureau of Standards formula) of high reflecting power which reflects the light back and forth many times within the cube, so that the entire inside area is evenly illuminated. The projection system, in this case, throws a beam of light through one aperture in the integrating cube and images a diaphragm upon the sample aperture (3) in the opposite face. On a third face is mounted a Weston photronic cell (5) with its sensitive surface facing the interior.

With no sample in position over aperture (3), the beam passes completely through the cube. When the sample is placed in position, light is reflected from it back into the cube and thus caused to fall on the active surface of the cell. The current thereby generated is read upon a Weston Microammeter having a scale range of approximately 15 microamperes. If the paper sample is absolutely opaque, the reading will not differ whether the sample is backed by white or black. If the paper is not completely opaque, some light from the incident beam will pass through. If the paper is backed by white, this transmitted light will be again reflected and added to that originally reflected by the front surface. If the paper is backed by a black body, this transmitted light will be absorbed. It is the ratio of the response under these two conditions which constitutes "contrast ratio" and "printing opacity." Immediately in front of the photronic cell is a filter which alters the cell response to give a sensitivity curve close to that of the human eye.

The black body (7) and the white body (8) are held on a pivoted mount (9) behind the sample aperture (3) so that they may be quickly interchanged. The black body has the inner cylindrical wall lined with black velvet to absorb as completely as possible all light passing through the paper. The white body is a magnesium carbonate cylinder with a carefully faced flat end, protected by a thin cover glass. A variable diaphragm operated by button (10) permits adjusting the intensity of the light projected on the sample and is designed to permit direct reading whenever the sample, backed by white body (8), reflects enough light so that microammeter (6) may be set to 10 on the scale. Then, black body (7) is substituted for the white, and the microammeter reading will be contrast ratio, no computation being necessary. If the reflection factor is too small to permit reaching the 10 point, then the black body reading and the white body reading are made and the first divided by the second to give contrast ratio. Direct reading of printing opacity may also be made in a similar manner.

The cover (14) is an aluminum casting which encloses the entire optical system, but leaves the operating face of the integrating cube (4) open and flush with its surface, so that it is possible to reach any point within about 9″ from the edge of the sample. The microammeter (6) is read through an opening (15) in the cover and is illuminated from the interior so that no auxiliary table lights are needed.

While primarily intended only for opacity measurements, the instrument may also be used for comparative measurements on the total reflecting power or brightness of various paper samples. In obtaining such values, the reading is first made on the magnesium carbonate (8) alone and then upon the sample backed by the black body (7). It may also be used for comparative measurement of the total reflecting power of opaque white or colored solids. It should be noted that this refers to "total reflecting power" or brightness, as the eye might see it, and has no reference to the measurement of color. The reflecting power will be the ratio between the sample reading and the white body reading, with no sample in place.




*Scientific Bureau, Bausch & Lomb Optical Co.

(Continued from Page 192)

2 (80 pages) describes the principal types of industrial measuring instruments; Chapter 3 (103 pages) describes relay, signalling and automatic control devices. The appendices consist of (1) bibliography, (2) instrument index and (3) manufacturers' directory.

On the whole, the book is chiefly a compilation of manufacturers' data—but this is an excellent feature, for it means a profusion of illustrations in the form of photographs as well as of schematic diagram. Needless to say, these measuring and regulating instruments are those which the student will find commercially available in Germany when he graduates. By the same token, the volume represents the state of the art in Germany—not in the world. For example, automatic humidity or air-conditioning control, which would be treated extensively in an American handbook of chemical industry regulators, receives exactly two mentions—each of them buried in a paragraph describing one type of regulating equipment on the German market—and there is only one illustration: a schematic diagram of a system for turning a humidifying spray on or off in paper manufacturing plants. This particular system is an old, old story in America.

Although this handbook thus offers little of practical value to users of industrial instruments in American industries, it nevertheless makes interesting reading for American designers of industrial instruments and control devices, because it contains so many descriptions of German devices little known in this country. The reviewer is aware, of course, that large and progressive American firms do not neglect to keep up with German patents, but the foreign patent files in our engineering departments are not used systematically—in fact we dare say that few of them are used intelligently and purposefully. Here, then, is a compendium which represents only the German "winning ideas" in the field of Instrumentation. In some respects American practice is far ahead (as in the air-conditioning example noted) but in other respects this volume should prove an "inspiration" to American development engineers. This is particularly true of electrical systems for the measurement and control of non-electrical variables which chemical engineers seek to conquer.—M. F. BÉHAR (2)-B-

**Textbook of Time Studies. (Lehrbuch des Zeitstudiums.)** By K. H. FRAENKEL and HANS FREUND. George Stilke, Berlin, 1932. Cloth, 6½x9½ inches, 262 pages. Price, 14 marks.

This is a notable contribution to the present literature on that subject because it goes a little more deeply into digging out methods for ascertaining still unknown quantities and in fortifying methods already in existence in the field of time studies. The book gives a clear picture of the present status of time studies in Germany which seem to have reached quite a progressive stage. One cannot help but to admit of what great advantage it would be to American Industry, if it would adopt a standardized nomenclature and procedure in making time studies as is evident from this book and is now practiced in Germany.

Great emphasis is placed upon the ascertainment of fatigue and strain factors as well as that of idle time. The writing of the book and the collected data give evidence of the authors' broad experience and their ability to interpret and make useful the results of their research work.

The first chapter deals with general definitions; Type of observer time study equipment, discussion of value of time studies and limits of application. The second chapter follows with basic requirements and the making of time studies. Analysis, synthesis and evaluation of time studies are treated in the third chapter which represents the most valuable section of the book. It furnishes a logical and demonstrable criticism of the various evaluation methods in use together with the more and more employed frequency distribution curves and other graphical methods. The mathematical tools for establishing an economic basis for planning production in correlation with time studies are discussed broadly and efficiently.

In the last chapter more space is devoted to the treatment of graphs and their application in this field. About 25 pages of this chapter give a description of time study instruments such as stop watches, graphical time recorders and mechanical operation recorders and a discussion of their relative values.

The book is well illustrated and especially the diagrams, graphs and curves are very clear and convincing with the accompanying text. An extensive bibliography is included.

In spite of all the book's merits I miss the important link of motion studies. Today a book on time studies should not omit so essential and important an element. Time studies cannot be separated from motion studies, when time studies in themselves should show economical results. This cannot be questioned. It would seem that the authors, considering their experience and ability, should not pass up an opportunity in writing a book on time studies which enabled them to include one of the most profitable subjects so intimately related to the treated one. This is to be regretted and it is hoped that a new edition will fill this vacuum in an otherwise highly recommendable book.—J. DECKER (12)-B-

**1933 A.S.H.V.E. Guide.** American Society of Heating & Ventilating Engineers, New York, 1933. Cloth, 6x9 inches, 852 pages. Price $5.00.

This 11th annual edition of the standard reference volume on heating, ventilating and air conditioning appears in an entirely new "dress" and the contents have been enlarged and revised to include late results of research and modern engineering practice. Compiled by the foremost engineers in the profession, the Guide embodies in its 45 chapters not only data developed at the A.S.H.V.E. Research Laboratory and coöperating institutions, but also the most practical and useful ideas of outstanding engineers in the profession. The Test Section contains 608 pages, supplemented by 180 pages of manufacturers' catalog data with a product index, also 64 pages of the A.S.H.V.E. Roll of Membership. Eleven new chapters are to be found and extensive chapters are to be noted in retained matter. Chapter 3, dealing with Transmission Losses, presents an entirely new set-up of tables with coefficients of transmission based upon the latest investigations of the A.S.H.V.E. Research Laboratory in Pittsburgh and the most recent data obtained at the Experimental Engineering Laboratories of the University of Minnesota. Chapter 14 gives additional information on Heating Boilers. The A.S.H.V.E.'s new Ventilating Standards, adopted in 1932, are included with other important data in Chapter 22, relating to Ventilating and Air Conditioning for Comfort and Health. Considerable information heretofore unpublished is found in Chapters 24 and 25 and the data on Air Duct Design (Chapter 33) have been amplified and made more useful by the introduction of more complete examples. Chapter 29 describing Test Instruments and Methods is new material, and Chapters 20 and 31 on control instruments for temperature and for air conditioning are largely revised.—M. F. BÉHAR (2)-B-

**Profit Engineering.** By C. E. KNOEPPEL. McGraw-Hill Book Co., New York, 1933, cloth, 5½x8½ inches, 326 pages. Price $3.00.

A double-page frontispiece in four colors engages one's attention on opening this timely work. It is the Knoeppel "Profitgraph" and we shall not attempt to explain the uses of this chart, for this explanation appears to be the principal purpose of the book, requiring at least 100 pages of it. To the disciples of Knoeppel, whose number has been increasing for the last 25 years, the Profitgraph is familiar. It may not have been the first graphic method of planning the next year's operations of a manufacturing business, but there is no doubt that most of the analogous charts which have been "invented" since the war have been inspired by it. "Profit Engineering," however, is more than a set of detailed directions on the use of the Profitgraph; it includes many passages that expound the author's philosophy. A good many of these are reminiscent of Knoeppel's "Installing Efficiency Methods" (1917) which the reviewer, for one, found extremely stimulating. Here are a few statements taken from several chapters on different topics, which convey some of Knoeppel's underlying concepts although their being detached from their context impairs their full significance:

"What is presented herein is not a theoretical concept, but tested practice which has been used and is being used by many successful concerns . . ." (Introduction)

"If there is no service, there should be no profits . . . if there is a service rendered, there should be no losses."

"It is only when a business does better than make this interest rate for capital that we can say there is a real profit, as the management's reward for skill, ability, and experience, and the owner's compensation over what he could earn in stocks and bonds for the risks involved. The one is the return for money; the other is the true business profit."

"Analyze, if you will, the great industrial successes like General Motors, duPont, General Electric, American Telephone and Telegraph, General Foods, United States Steel, International Business Machines, Western Electric . . . and you will find: . . . 2. That they consider themselves as: (a) Trustees of the owners of the business. (b) Guardians of the workers, whether blue shirt or white collar. (c) Servants of the customers they sell to."

"The author wishes to present a word painting of a flesh-and-blood example of the ideal manager . . . A study of the man's career, and of the statements made about him by enemy as well as friend, reveal the following: He organized and delegated; he supervised and watched progress; he took counsel wherever he could get it; he abhorred details and arranged for subordinates to handle them; he watched for opportunities and was quick to make the most of them; he compromised whenever necessary; he coordinated warring factions; he respected his opponents' strength; and he kept himself in readiness to jump into any situation, at any time, at any place."

Returning to the Profitgraph, here is what the author himself has to say about it in Chapter VII. ("The Profitgraph as a Variable Income Statement"): "The Profitgraph is merely a chart—angles and lines and percentages and dollars—and in itself a static and useless thing, until someone takes it and uses it as he would an automobile route map. The preparatory work leading to the making of the Profitgraph is as important as that involved in preparing a road map. Even more important is the work of studying the Profitgraph and using it as a guide to a profit objective, in the same way the automobile driver who has a definite destination in mind but is lost on a detour uses his map."

There is a foreword by F. W. Shibley, Vice-President of the Bankers Trust Co., who makes the startling statement that "as a nation we are not acutely profit-minded. Our primary and dominating instinct is to do things." There are also supplementary chapters by A. J. Minor on Mathematics Behind the Profitgraph, and by E. St. Elmo Lewis, advertising authority, on "Securing Sales Called For by Profitgraph." Knoeppel also quotes many other business and engineering authorities, and one's final impression is that the author has sedulously refrained from harping too much on his own devices and expedients and methods and technique, and depending too little on those of others.

A review for the readers of *Instruments* would not be complete without mentioning the "Knoeppel Profitmeter"—the illustration of which on page 171 looks exactly like part of a switchboard with 8 dial instruments. Of course, the pointer and dial method of indicating statistics is an old story; various newspapers have used it and safety engineers frequently hang up such indicators near the time clocks where all employees can see them, but Knoeppel has thought out a set of 8 dials which include only 3 sets of absolute figures, the other 5 being ratios or percentages, so that a "profit engineer," visiting a number of plants, could quickly compare them with one another with respect to what Knoeppel calls the "health" of each company. —M. F. BÉHAR (12)-B-

# INSTRUMENTS ABSTRACTS

Abstracts on instruments and devices for measurement, inspection and control.

## LIGHT, OPTICS, AND RAYS (7)

### Electromagnetic Rays (7.8)

**Notes on the Theory of Radiation.** C. G. DARWIN. *Proceedings Royal Society*, Vol. 136A, May 1932, pages 36-52.

The aim of the work was to apply the methods of wave mechanics to the single photon, following out as far as possible the progress which has succeeded for the electron. The usual real form of electromagnetic waves implies the presence of two waves of equal amplitude, but respectively of positive and negative energy and momentum, and it is suggested that the latter should be rejected. The polarization of light is connected with its angular momentum in a way resembling the spin of the electron. The separation of angular momentum into two parts, one external, due to the motion of the center of gravity, and the other intrinsic, is shown to be conventional; no experiment can divide it in this way, and since the external momentum is always uncertain, the intrinsic momentum of a photon is unobservable. Certain features of the radiation of an atom are considered. The perturbation of the photon by an electron is considered and the energy of perturbation is given for the case of Thomson scattering. WAT (7.8)

**A Design of Metal X-Ray Tube.** N. S. GINGRICH. *Review of Scientific Instruments*, Vol. 1, Nov. 1930, pages 691-693.

A metal X-ray tube, designed more especially for the study of scattered X-rays, is described. The two metal parts, one of which can be connected to voltages up to 60 KV, the other to ground, are separated by tube of pyrex glass. Ha (7.8)

**High Voltage X-Ray Tube.** GENERAL ELECTRIC CO. *Instruments*, Vol. 5, March 1932, page 81.

Illustrated description of new water-cooled tube operating satisfactorily at 340,000 volts and 10 milliamperes. MFB (7.8)

**Industrial X-Ray Apparatus.** GENERAL ELECTRIC X-RAY CORP. *Instruments*, Vol. 5, March 1932, page 80.

Illustrated description of new equipment. A 200,000-volt X-ray tube is used. Rooms containing apparatus are carefully lead-lined. Operator watches equipment through a lead-glass window. MFB (7.8)

**The Shape of an X-Ray Line.** ARCHER HOYT. *Physical Review*, Vol. 40, May 1932, pages 477-483.

An X-ray emission line can be represented very accurately by means of a simple formula of the type $\gamma = a/(1 + [x/b]^2)$ where the ordinate $\gamma$ represents the intensity $I$ ($\lambda$) as a function of $x \equiv (\lambda_0 - \lambda)$, $b$ the half-width at half-maximum, $a$ the maximum ordinate of the spectral line, and $\lambda_0$ the wave-length of that ordinate. Some uses of the formula are (1) location of the background under the $K\alpha$ doublet, (2) the calculation of the separation of close components from measured points used in the empirical formula. This formula appears to be a function of a very useful type since it is also a good representation of rocking curves obtained in the "parallel" position of the spectrometer. A search for theoretical justification of this type of formula has brought to light the curious result that although the application of the Dirac quantum theory of the radiation field yields a formula of the same type, the maximum ordinate predicted is independent of the spontaneous transition probability; whereas, certain experimental work indicates that the maximum ordinate is a good measure of the line intensity. This is disturbing since the assumption is usually made that the line intensity is proportional to this Einstein coefficient of spontaneous transition. WAT (7.8)

**A Step Further in X-Ray.** HERBERT R. ISENBURGER. *American Machinist*, Vol. 76, Jan. 28, 1932, page 133.

By shifting the tube in relation to the film during exposures two images of the same section are recorded. By this method the location and extent of any defect may be determined. RHP (7.8)

**The Cathode Ray Effect Connected with X-ray-Spectroscopic Analysis. (Ueber den bei roentgenspektroskopischen Analyse auftretenden Kathodenstrahleneffekt.)** M. ISHIBASCHI. *Zeitschrift anorganische und allgemeine Chemie*, Vol. 202, Dec. 24, 1931, pages 372-374.

The author describes the change which a composition of titanium oxide, barium sulfate and iron oxide undergoes when subjected to analysis by cathode rays. The intensity of certain lines is increased. A number of measurements on meteorites is described. Ha (7.8)

**High Speed X-Ray Machine.** WESTINGHOUSE X-RAY COMPANY. *Instruments*, Vol. 5, Feb. 1932, page 60.

An X-ray snapshot in less than 1/1000th of a second is made possible by this new machine, which uses a 3-element X-ray tube. HO (7.8)

**A New Radiographic Metallurgical Laboratory. (Un nouveau Laboratoire de Radiometallographie.)** J. J. TRILLAT. *Revue d'Aluminium*, Vol. 8, Mar., Apr. 1931, pages 1357-1363.

Several examples are described to show the advantage of X-ray testing for metallurgical purposes; the equipment of laboratory is described which has been installed in Bourget by three French companies to investigate aluminum, copper and steels. Ha (7.8)

**Scientific and Industrial Applications of X-Rays. (Les Applications Scientifiques et industrielles des Rayons X.)** J. J. TRILLAT. *Science et Industrie*, Vol. 14, 1930, pages 417-420, 510-512, 669-672, 772-778, 835-839.

Reviews and treats in detail properties of X-rays, tubes, method of testing and applications for metals, determination of structures and inner stresses, and general metallurgical applications. Ha (7.8)

**A Simple Ray-and High-Voltage-Free Apparatus for Structure Pictures. (Ein einfacher strahlen-und hochspannungssicherer Apparat für Strukturaufnahmen.)** A. BOEWES & W. BUSSE. *Zeitschrift für Kristallographie*, Vol. 177, May/June 1931, pages 507-514.

The X-ray tube is grounded in the centre so that the preparation can be placed closer to the focus of the tube on account of the reduced voltage, and the time of exposure is greatly shortened. Ha (7.8)

**An X-Ray Method for the Investigation of Lattice Disturbances in Crystals. (Über eine röntgenographische Methode zur Untersuchung von Gitterstörungen an Kristallen.)** W. BERG. *Naturwissenschaften*, Vol. 19, No. 19, 1931, pages 391-396.

It was intended to produce the picture of a crystal surface by means of X-rays in the same way as it is done with visible rays; the source of the X-rays is not a point but a line. If monochromatic X-ray light is used under a certain angle each point of the picture can be coordinated to a definite point of the crystal surface. How the surface can be constructed from the picture is explained in detail. Ha (7.8)

**Crystal Analysing Apparatus.** *Electrical Review*, Jan. 8, 1932, page 48.

Describes self-contained X-ray apparatus of Philips Lamps, Ltd. Comprises a transformer enclosed in a water-cooled pedestal, a cooling fan, camera holders, a special tube with a copper anode and two nickel apertures, an alternative tube with a molybdenum anode, two thin glass apertures, and two zirconium filters; two Debye-Scherrer cameras, each with two diaphragms and three special clamps, a switch with plug, cables, and three-pole earthed wall socket for direct connection to 220-volt a.c. supply. Consumption is 450 watts and the current, 2.8 amperes. MS (7.8)

**Notes on Radiation Thermopiles.** JOHN STRONG. *Review of Scientific Instruments*, Vol. 3, Feb. 1932, pages 65-70.

A design of thermopile is described which has the following principal features: two junctions give maximum sensitivity, junctions may be welded by a condenser discharge. The theory of the radiation thermopile is briefly given. Ha (7.8)

**A New Type of Radiometer.** ALEX. L. DINGEE. *Review of Scientific Instruments*, Vol. 3, Feb. 1932, pages 80-84.

The variation of the frequency of an oscillatory circuit is used for the control of a vacuum tube circuit by a blackened thermal device. The change of frequency is obtained by a condenser which changes its capacity when the light intensity falling on it varies. The theory of the method and an instrument developed from it is described. Ha (7.8)

**A 200,000 Volt X-Ray Tube.** WM. W. HANSEN. *Review of Scientific Instruments*, Vol. 2, Dec. 1931, pages 820-823.

The glass tube is of pyrex and the tube is connected to a pumping system to maintain the vacuum. The window through which the rays emerge is of aluminum of 0.002" thickness. The mechanical construction is described in detail. The current for satisfactory operation is $20 \times 10^{-6}$ amp. Ha (7.8)

**Relativity and the Uncertainty Principle.** N. ROSEN & M. S. VALLARTA. *Physical Review*, Vol. 40, May 1932, pages 569-577.

A simple ideal experiment to measure simultaneously the position and momentum of a free electron, also its kinetic energy and the instant when this kinetic energy is measured, taking into account the finite velocity of propagation of light as embodied in the Lorentz transformation, is proposed. This experiment is as follows: an observer sends out a light signal which strikes a given free electron and returns along its own track. From measurements made on the outgoing and returning signals the required quantities, and the uncertainties in their measurement, are calculated. In the absence of detailed knowledge concerning the nature of the interaction between the signal and the electron, it is found that for any electron velocity between 0 and $c$, $\triangle p \triangle x$ and $\triangle E \triangle t$ have an upper and lower bound. The upper bound depends only on the initial electron velocity and the lower bound is a function of the electron velocity and the outgoing frequency. These bounds come close together for low electronic velocities, but their separation increases as the initial electron velocity increases becoming infinite in the limit $v = c$. In the limit $c \rightarrow \infty$ the upper and lower bounds coalesce for all frequencies and all electron velocities giving Heisenberg's results. WAT (7.8)

**A Gas X-Ray Tube for Crystal Structure Analysis.** H. KERSTEN. *Review of Scientific Instruments*, Vol. 3, March 1932, pages 145-150.

The necessary intensity of X-ray beams for crystal structure analysis was obtained by providing sufficient cooling to allow for large current carrying capacity by making use of cellophane windows and by placing the slit in the evacuated system so that a close approach to the target is possible. The construction is described in detail and a few Laue-pattern photographs illustrate the results obtainable. Ha (7.8)

**Investigation of an Erythemometer. (Untersuchung eines Erythemmessers.)** A. DRESLER. *Elektrotechnische Zeitschrift*, Vol. 53, March 31, 1932, pages 321-322.

This instrument, used for the measurement of the amount of ultraviolet radiation, especially as a dosimeter for medical treatment, consists of a small glass tube in a metal case, filled with a solution of leucosulfite of crystal violet; this solution becomes blue under the action of ultraviolet radiation. The spectral sensitivity of the instrument was determined and the tests and calibration as a dosimeter are explained. Ha (7.8)

**Reasons for the Widening of X-Ray Lines Obtained by the Debeye-Scherrer-Hull Method and by the Bragg Method (Die Ursache der Lienienverbreiterung bei Pulver- und Drehkristallaufnahmen mit Röntgenstrahlen).** U. DEHLINGER. *Zeitschrift für Metallkunde,* Vol. 23, May 1931, pages 147-149.

Author ascribes the broadening lines of X-ray photograms to 3 causes: (a) small deviations in the space lattice constants due to concentration differences in solid solutions on the one hand and elastic distortions on the other hand; (b) abnormal small grain size as encountered in metals deposited by sublimation or electrolysis in metals colloidically dispersed and probably in some eutectoids as, for instance, in pearlite and in martensite; (c) "quick fluctuations" in the lattice, i.e., inhomogeneous lattice distortions caused by the inhomogeneous distribution of a mixed crystal's component or as a result of elastic internal stresses. In conclusion, the author critically discusses the influence of rolling upon the broadening of X-ray spectogram lines which phenomenon he ascribes to an inhomogeneous distortion or "bending" of the individual crystals created during the process of rolling. EF (7.8)

**The Accuracy of Interference Measurements in the Molecule with X-Rays and Cathode Rays. (Ueber die Genauigkeit von Interferenz-Messungen in der Molekel mit Roentgen- und Kathodenstrahlen.)** L. BEWILOGUA. *Physikalische Zeitschrift,* Vol. 32, Jan. 15, 1931, pages 114-117.

The following question is discussed, "Do the wave-lengths of cathode rays yield a larger resolving power due to their being 10 to 30 times smaller than the wave-lengths of X-rays?" The limitations of an affirmative reply are revealed and the following question is brought up, "What kind of rays yield the most favorable contrast of intensities?" which means a curve with pronounced maxima and minima. The advantages of using cathode rays for the determination of intermolecular spacings are pointed out, but the necessity of applying X-rays in certain cases of complicated space lattice measurements is discussed. EF (7.8)

**On a Method of Measuring the Absorption-Spectra in the Ultra-Violet Range. (Uber eine Methode zur Messung von Absorptionsspektren im Ultraviolett.)** H. CONRAD-BILLROTH. *Zeitschrift fuer physikalische Chemie,* Section B, Vol. 14, Sept. 1931, pages 122-134.

Detailed description of a specially designed photometer which permits photographic quantitative measurement of spectra in the ultra-violet. Equipment comprises a quartz spectrograph and a photometer; latter records curves showing deflection of a galvanometer in dependence on the wave-lengths. Principles employed are detailed; sensibility of method is discussed; conclusion points out drawbacks of this kind of measurements. EF (7.8)

**On the Clearness of Diffraction Maxima of Electron Waves. (Ueber die Schaerfe der Beugungsmaxima von Elektronenwellen.)** E. SCHOEBITZ. *Physikalische Zeitschrift,* Vol. 32, No. 1, Jan. 1, 1931, pages 37-39.

After several failures the author succeeded in developing a method which yielded diffraction maxima on electron waves as distinct as those of X-ray spectrograms. Au-foils $10^{-5}$ to $10^{-6}$ cm. thick and wave-lengths of 0.1 to 0.04 A.U. were employed. EF (7.8)

**The X-Ray Fibre Diagram as a Quantitative Measure for the Changes in the Cellulose Fibre Due to Chemical Reactions. I. Communication. The Quantitative Relation Between the Various Intensities of the Equatorial Interferences of Fibre Samples Consisting of Native and Mercerized Cellulose. (Das Röntgenfaserdiagram als quantitativer Masstab fuer die Veraenderung der Bausteine der Cellulosefaser durch chemische Prozesse. I. Mitteilung. Die quantitativen Beziehungen zwischen den Intensitaeten der Aequatorialinterferenzen bei bekannter Zusammensetzung von Faserpraeparaten aus nativer und merzerisierter Cellulose.)** W. SCHRAMEK. *Zeitschrift fuer physikalische Chemie,* Section B, Vol. 13, Aug. 1931, pages 462-474.

Utilization of X-rays for research problems pertaining to the industry. 19 illustrations. EF (7.8)

## CHEMISTRY (8)

**The Measurement of the Hydrogen-Ion Concentration in Unbuffered Solutions. II. Application of the Hydrogen Electrode.** I. M. KOLTHOFF and TOHRU KAMEDA. *Journal American Chemical Society,* Vol. 53, March 1931, pages 821-824.

Use is made of the fact that acid adsorbed by Pt can be removed by washing with water in a hydrogen atmosphere. Directions are given for the preparation of an electrode coated with a bright layer of Pt, the use of which yields satisfactory results in the measurement of pH in unbuffered or slightly buffered solutions. The electrode is easily poisoned, and cleaning and replatinizing are often required, but reproducible results can be obtained even in solutions of KCl. MEH (8)

**The Measurement of Hydrogen-Ion Concentration in Unbuffered Solutions. III. The Colorimetric Method.** I. M. KOLTHOFF and TOHRO KAMEDA. *Journal American Chemical Society,* Vol. 53, March 1931, pages 825-832.

A technique is described for the colorimetric measurement of pH in pure water, of neutral salts in pure water, and of extremely dilute solutions of NaOH. MEH (8)

**Acidity in Non-aqueous Solvents. Conductimetric and Electrometric Titrations of Acids and Bases in Benzene.** VICTOR K. LAMER and HAROLD C. DOWNES. *Journal American Chemical Society,* Vol. 53, March 1931, pages 888-896.

An electrometric method is described for titrating acids and bases in benzene using quinhydrone electrodes. MEH (8)

**The Manometric Measurement of the Oxidation Velocity of Unsaturated Oils. (Über die manometrische Messung der Oxydationsgeschwindigkeit ungesattigter Öle.)** J. JANY. *Zeitschrift fur angewandte Chemie,* Vol. 44, May 9, 1931, pages 348-351.

Describes and recommends the use of the Barcroft manometer for determining the rate of oxidation of oils, both fatty and mineral. (8)

**The Gum Stability of Gasolines.** E. W. ALDRICH & N. P. ROBIE. *S. A. E. Journal,* Vol. 30, May 1932, pages 198-207.

Includes illustrated description of accelerated oxidation apparatus, termed an oxidation bomb. WAT (8)

**A Continuous Gas Indicator.** *The Industrial Chemist,* Vol. 8, February, 1932, pages 57-58.

New instrument (B.P. 330799) developed by Admiralty Research Laboratories. Principle: comparison of viscosity-density properties of the gas under test against air in a specially constructed bridge. Diagrammatic layout is shown. RAW (8)

**Analysis of Gas Mixtures. (Analyse von Gasgemischen.)** OLOF RODHE. *Archiv für Technisches Messen,* 1931, section V723-3, page T52.

The principle of gas analysis by the absorption method and the required apparatus are explained; the automatic method, and multiple analyses are described and the accuracy discussed. 14 references. Ha (8)

**Recent Developments in Automatic Rectifier Control.** L. H. BRENDEL. *Petroleum Engineering,* Vol. 3, Nov. 1931, pages 57-58, 60.

Automatic control rectifier problems discussed, particularly constant reboiler temperatures. (8)

**Continuous Carbon Monoxide Indicator.** MINE SAFETY APPLIANCES COMPANY. *Instruments,* Vol. 5, Jan. 1932, page 22.

The gas passes into a cell where, by catalysis, CO is converted into $CO_2$. The heat liberated by this process is proportional to the percentage of CO present, and is measured by a series of thermocouples connected to the indicating meter. (8)

**A Thermal Method for Quick Measuring of Carbon-Monoxide. (Ein thermische Methode zur schnellen Kohlenoxydmessung.)** G. STAMPE. *Messtechnik,* Vol. 6, Oct. 1930, pages 267-270.

The CO-mixture to be determined is burnt at low temperature over a catalyser. From the heating of the gas flowing away from the catalyser the CO-contents of the incoming gas can be determined. The apparatus is described, its theory explained and the method illustrated by a few examples. Seven references. Ha (8)

**Quantitative Spectrum Analysis. (Quantitative Spektralanalyse.)** *Elektrotechnische Zeitschrift,* Vol. 53, Mar. 24, 1932, pages 295-296.

A method and apparatus are described to determine, by means of emission spectral analysis, the nature of a metal or alloy and its quantity. The element is determined by the spectral line characteristic for this element, and its quantity by photographic determination of the intensity of the line. Only a very small quantity of the substance is needed as electrodes between which a high-voltage current produces sparks for the spectrum. The practical use of this method for the supervision of the quality of materials is explained. Ha (8)

**Analysis of Gas Mixtures. (Analyse von Gasgemischen.)** OLOF RODHE. *Archiv für Technisches Messen,* 1931, section V723-3, page T52.

The principle of gas analysis by the absorption method and the required apparatus are explained, the automatic method, and multiple analyses described and the accuracy discussed. Fourteen references are cited. Ha (8)

**Exhaust-Gas Analysis.** C. B. DICKSEE. *Automobile Engineer,* Oct. 1931, page 401.

The Orsat flue-gas-analysis apparatus, which has been in such universal use in the boiler house for many years, has received very little attention from the automobile engineer. The author contends that it will yield more information than almost any other single piece of apparatus that is available to the worker on internal-combustion engines. He describes the Orsat equipment and sets forth its application to such engines, including two-stroke-cycle and compression-ignition engines. (8)

**The Conductometer. (Das Konduktometer.)** A. SCHLEICHER & W. LUEDICKE. *Die Chemische Fabrik,* Vol. 4, May 6, 1931, pages 201-203.

A paper read at the Verein Deutscher Chemiker takes up the relationship between the indication during the volumetric analysis and the physical concentration measurements, which relationship offers the possibility of carrying out those determinations by means of conductivity measurements similar to the colorimeter. A suitable apparatus, designated as conductometer, is introduced and its mode of operation demonstrated in several experiments. Basic principle: changes in capacity of a vessel yield knowledge of conductivity and concentration which can be compared with a known solution. EF (8)

**A New Type of Apparatus for Drawing Liquid Samples in Combination with an Analysis Burette. (Ein neuer Sammelprobenehmer mit Analysenbuerette.)** *Die Chemische Fabrik,* Vol. 4, Nov. 4, 1931, page 434.

The glass apparatus invented by Dr. Schiller is especially constructed for securing a fair mean sample out of a number of liquid samples. The absolute absence of air and the elimination of molesting vapors are claimed as further advantages. EF (8)

**A Burette for Standard Solutions which are Sensitive to Air. (Eine Buerette fuer luftempfindliche Titerlöesungen.)** P. DICKENS. *Die Chemische Fabrik,* Vol. 4, April 22, 1931, page 185.

A titration apparatus distributed by the Stroehlein Co., Duesseldorf, is described which absolutely excludes the air so that the "standard solutions" for titration analysis really remain standard. EF (8)

**A New Apparatus for the Determination of Water by the Xylol-Method. (Eine neue Apparatur zur Wasserbestimmung nach der Xylol-methode.)** FRITZ ECK. *Glas und Apparat,* Vol. 13, April 3, 1932, pages 51-52.

The arrangement eliminates the inherent danger of the high inflammability of the xylol by using a copper flask instead of glass and a cooling device, so that this exact method for the determination of the water content of fuels, paints, drugs or ceramic materials can be used without danger. Ha (8)

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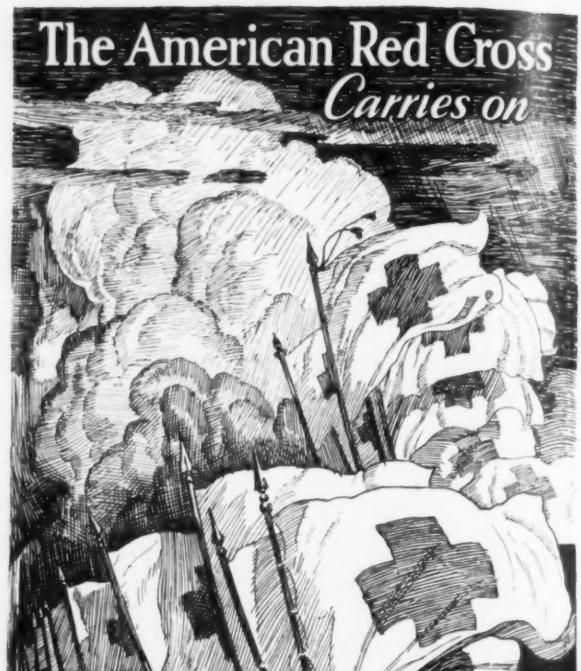




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Before me, a Notary Public in and for the State and county aforesaid, personally appeared Richard Rimbach, who, having been duly sworn according to law, deposes and says that he is the publisher of the INSTRUMENTS and that the following is, to the best of his knowledge and belief, a true statement of the ownership, management (and if a daily paper, the circulation), etc., of the aforesaid publication for the date shown in the above caption, required by the Act of August 24, 1912, embodied in section 411, Postal Laws and Regulations, printed on the reverse of this form, to wit:

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Volume X SEPTEMBER, 1933 Number 9


The English journal devoted to scientific instruments, their principles, construction and use. Essential to all up-to-date designers, makers and users of instruments.

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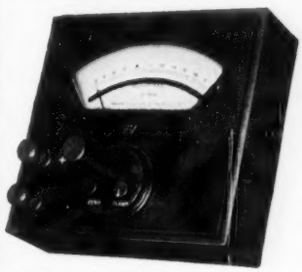

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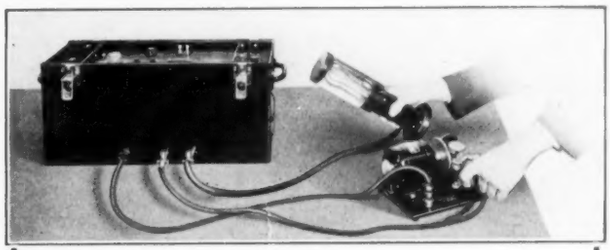

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